# HERBAGE REVIEWS

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IMPERIAL BUREAU OF PASTURES AND FORAGE CROPS
ABERYSTWYTH, GREAT BRITAIN

## OUR CONTRIBUTORS

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Erik Åkerberg, Fil. lic., Agronom., has been Head of the Department of Forage and Pasture Plants, Plant Breeding Institution, Weibullsholm, since 1932. In 1939 he will become the Director of the Västernorrland branch station of the Swedish Seed Association. He is specially engaged in the study of the seed formation of *Poa pratensis*, the occurrence of apomictic and sexual types in this species, the origin of hybrids between *Poa pratensis* and other *Poa* species, etc. Among his publications may be mentioned (1) Studien über die Samenbildung bei *Poa pratensis* L. Botaniska Notiser 1936 (*Herb. Abstr.* 7. 1937), and (2) Bastard mellan *Poa pratensis* L. *X Poa alpina* L. artificiellt framstalld. *Ibid.* 1936. (*Herb. Abstr.* 7. 1937.)

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Professor Dr. Wilhelm Riede, Botanical Institute of the Agricultural College, Bonn, Germany, has been engaged for many years in the breeding of soybeans at Bonn, where he has tested vast numbers of different types and has bred the "Dieckmann" varieties which are now on the market and have proved extremely successful in Germany and under temperate climatic conditions elsewhere. Dr. Riede has published numerous articles on the breeding of soybeans.

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EDITOR : R. O. WHYTE



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# ILLUSTRATED NOTES ON THE TECHNIQUE OF GRASS-BREEDING AT ABERYSTWYTH

A. R. BEDDOWS and A. G. DAVIS

Welsh Plant Breeding Station, Aberystwyth.

THIS Bureau has given a considerable amount of attention to the technique employed in the breeding of herbage plants, more particularly in Bulletin No. 3 entitled, The Breeding of Herbage Plants: Technique Adopted at the Welsh Plant Breeding Station, January 1931. In this Bulletin, T. J. Jenkin described the methods and technique of selection, breeding and strain building in grasses, R. G. Stapledon, methods as applied to cocksfoot grass (*Dactylis glomerata* L.), and remarks as to technique in general, and R. D. Williams described the methods and technique employed in breeding red clover, white clover and lucerne.

In view of the continued interest in the technique of breeding grasses, certain of the more detailed aspects of the methods employed by Dr. Jenkin are illustrated and described on the following pages.

The Bureau is sincerely indebted to Mr. A. R. Beddows and Mr. A. G. Davis for the technical details and the illustrations respectively.

**References**

1. JENKIN, T. J. The artificial hybridization of grasses. Welsh Plant Breeding Station, Bull. Ser. H. No. 2. pp. 1-18. Aberystwyth, 1924.
2. ———— The method and technique of selection, breeding and strain-building in grasses. Imperial Bureau of Plant Genetics : Herbage Plants. Bull. No. 3. pp. 5-34. Aberystwyth, 1931.
3. ———— Some aspects of strain-building in the herbage grasses. Rep. Fourth Int. Grassl. Congr. Gt. Brit. 1937. Plenary paper, pp. 54-60. Aberystwyth, 1937.

*Plate I*

The following notes are in amplification of those given by Jenkin (**1**, etc.), who first applied the technique of controlled crossing (emasculation and hand pollination) to the herbage grasses, and are intended to demonstrate the methods used by him.

The apparatus shown in fig. 1 are used in connexion with the hybridization of grasses. The forceps (A) required for the removal of anthers from the florets may be of any convenient size and shape, but the nature of the points is important. In the case of *Lolium* spp. and of others with florets of approximately similar type and size the tips should be relatively flat and blunt, but for *Phleum* they would need to be rather less blunt. In the latter case greater care would be required, as the sharper point would be more liable to pierce the anther. The desired tip shape is attained by grinding down the sharp points of the ordinary forceps by means of a fairly fine carborundum stone.

The paper (B) shown beneath the scissors is about 5 by 3.25 ins. in size, and when trimmed as in (C) serves to hold the pollen. These pollen papers are cut from large sheets of moderately stiff, perfectly smooth, glazed, dark blue sugar-bag paper of good quality. A certain degree of rigidity is necessary for safety in handling when containing pollen, which shows up against the blue background even if present only in very small quantity. The smooth surface makes the pollen more fluid, and facilitates transfer on to the stigmas. The pollen paper should always rest on some suitable rigid support to receive the pollen ; that shown in (C) is a cardboard box with V-shaped notches at either end. The untrimmed papers are kept in a box, and shaped as required for each new pollen.

The transfer of the pollen from the paper to the stigmas is done by means of a small artist's paint brush (size 0 or 1) of camel hair or sable. After use the brush is dipped in 90 per cent alcohol to kill the pollen and ensure fairly rapid drying. Each fresh lot of pollen necessitates a clean brush, and as no brush is used twice on any one day a considerable supply is needed. The maximum number Dr. Jenkin has used during one pollinating session (one evening's work) is 32. The number of units pollinated was considerably higher than this since each pollen supply is generally used on more than one female.

Figure 2 is intended to show the relative positions of inflorescence, spikelets and forceps in the hands of the operator during emasculation. The plant always stands to the left, and the spike is bent over so that it lies without strain along the first finger of the left hand. The forceps are held pencil fashion, almost perpendicular to the spike, in the right hand, which is partly supported by the outstretched middle fingers of the left. To work in this position may require some little practice, but it enables the anthers to be removed by their upper halves from the side of the floret. This is safer than working from the apex, especially for beginners, who until they develop a sense of touch, tend to penetrate too far down into the base of the floret with great risk of injuring the stigmas.

The upper florets of the spikelet to be emasculated are discarded, leaving only the number required, which may vary from two to six. This reduced spikelet is always held so as to be on the side of the rachis away from the emasculator (see fig. 2). The separation of the paleae is started by the thumb nail, by means of a slight lateral pressure, and completed by the forceps. Care must be used in removing the anthers to avoid breakage with the consequence of possible self-pollination. If there is risk of the latter as the result of faulty removal, the floret should be discarded or its ovary taken out. The florets are done in sequence from the uppermost to the lowest. In order that each new spikelet shall be correctly placed for emasculation, the position of the inflorescence is altered by half-turns backwards and forwards alternately. This operation also prevents the twisting of the rachis.

The emasculation has been successfully done if the stigmas are undamaged and later become reasonably well exerted, and no anthers have been left behind.

The following routine details may be helpful. The inflorescence that is being emasculated is marked by cutting off half its flag-leaf (see fig. 2). On completion, the remainder of the leaf is removed at the ligule. This identifies the emasculated heads and reduces transpiration when these are enclosed inside the bag ; the risk of aphid attack is also reduced, since the latter often lodge at or near the base of the leaf.

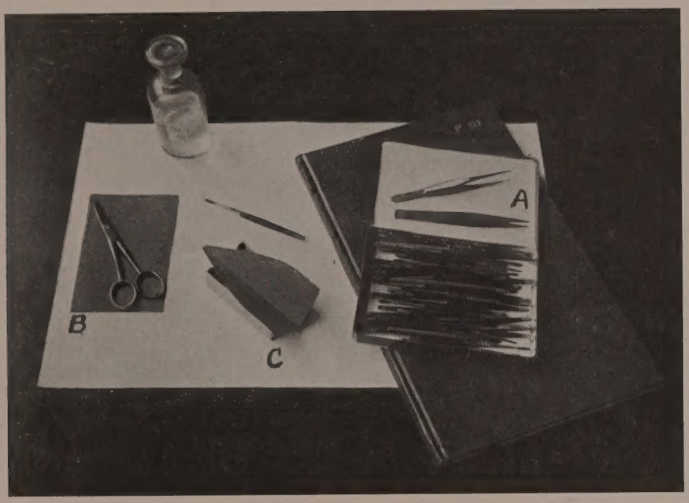


FIG. 1

FIG. 2

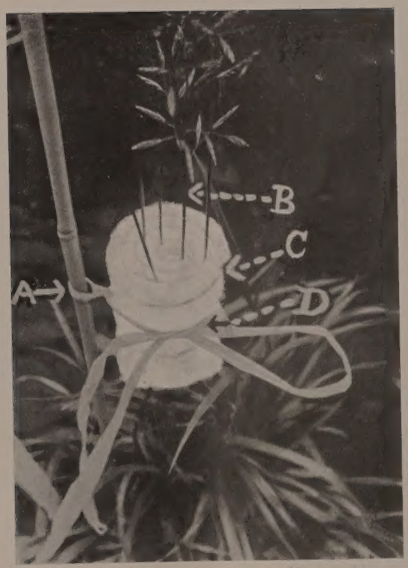


FIG. 1

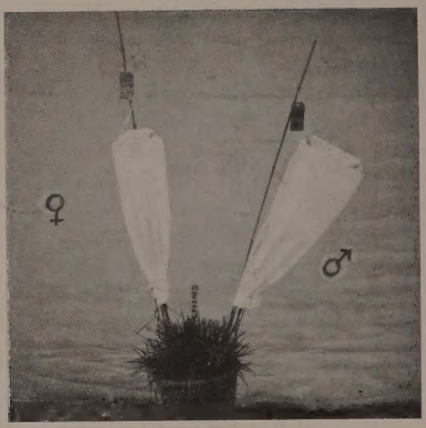


FIG. 2

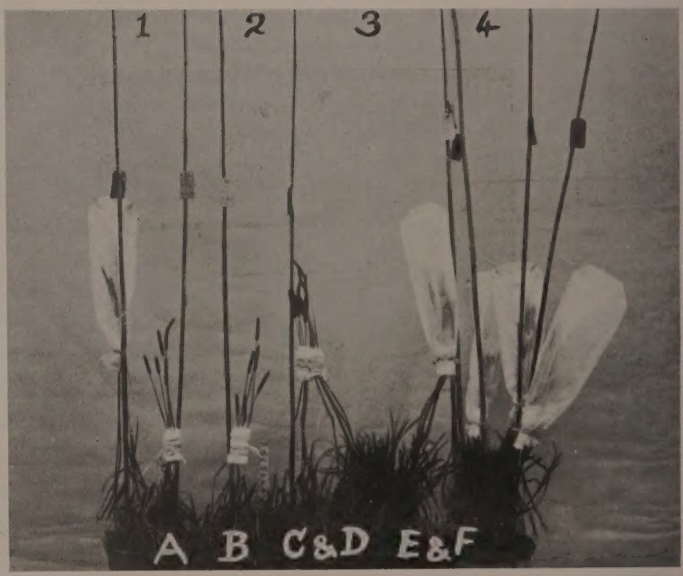


FIG. 3

*Plate II*

The figures in plate II illustrate the methods of assembling the different units employed under greenhouse conditions.

The first step in the bagging process is to insert a bamboo cane of suitable length (a 4ft. cane is used for *Lolium* spp.), near the selected inflorescences. A length of bast (raffia) is then tied round the cane so that the loop moves easily over any of the nodes (fig. 1, A), in order to allow of readjustment if necessitated by elongation of the stems. The inflorescences forming the unit are wrapped in a strip of cotton wool about 12 ins. long by 2.5 to 3 ins. wide. One end is folded over and wrapped round the most centrally situated stem (fig. 1, B) and then around the others in turn, so that each stem is isolated and intertwining below the cotton wool is reduced to a minimum. In the case of female units for hand pollination well spaced heads help to make the stigmas more readily accessible. The cotton wool pad is secured with bast (fig. 1, C) and the prepared unit supported by the tie from the bamboo (fig. 1, D) until bagged. Raffia is preferred to string because it can give a firm tie without danger of crushing the stems. The panicles in fig. 1 are those of *Festuca pratensis*.

The bags used are made of slightly opaque paper (glassine) and vary in size according to the species and type of unit dealt with. The sizes in general use are (in inches) 16 × 3, 20 × 6, 22 × 6 (for female units), 8 × 20, 9 × 20 and 8 × 22 (for pollen units).

The sloping position of the bamboo and bag of the male unit in fig. 2 is intentional, as is the pleating of the mouth of the bag causing most of the paper to be on the outer (lower) side. This arrangement causes the pollen released from the anthers to fall into the pouched under side of the bag and not into the cotton wool as it would if the unit were erect. The transference of pollen from bag to pollen paper is a simple matter. The loosened bag is bent into the horizontal position, tapped on the cotton wool pad to bring down all the pollen, removed and the contents run on to the waiting paper.

The method employed to intercross a series of plants in chain fashion is demonstrated in fig. 3.

The four timothy plants have been grouped together for mutual pollination. The prepared units A and B on plants 1 and 2 are ready for tying together in the manner shown for units C and D (plants 2 and 3). All that then remains to be done is to cover with a bag as for E and F. The position of the supporting cane will depend on the best position for combining the two units in order to give the maximum opportunity for interpollination. Matching the units may necessitate moving one of the pots away somewhat from its neighbour. Care should therefore be exercised in choosing the heads to make the fitting of the pairs as easy as possible. The units in fig. 3 are far from ideal, but they were the only ones available when this demonstration was set up in the autumn of 1938. It should be noted that in normal practice each plant in the chain would carry additional units to provide as many hand-crosses as possible with non-neighbour plants or for self pollination. The absence of these other units, however, has given fig. 3 a simplicity and clearness it would not otherwise have possessed.

The automatic pollination method (**3**, p. 56) is similar in arrangement to the above except that one of the units in each pair is emasculated. In " A.P." units skilful arrangement is sometimes called for in order to fix the female unit slightly below the male and thereby to ensure optimum pollination. Owing to the necessity for emasculation this method is applicable only to species which can be emasculated with relative ease. The advantage of " A.P." is that it does away with the tedious time-consuming daily hand pollinations, and in consequence much larger female units can be used. Given compatible plants flowering simultaneously, good seed setting is obtained. It is customary to shake all paired units during or soon after anther dehiscence. The drawbacks of the " A.P." method are that its accuracy depends on perfect emasculation and that it is not possible to note errors as in the case of hand pollination units which are opened each day. For these reasons hand pollination is to be preferred for highly critical work.

The units are generally arranged to form a double chain, and an attempt is made to obtain reciprocal crosses for each pair. Crosses between non-neighbour plants necessitate special hand pollination units.

On completion of flowering the combined units in both the mutual and automatic pollination systems are separated, and each is then protected by a bag supported by a bamboo in its own pot.

*Plate III*

The selfing of plants satisfactorily out of doors has presented difficulties on account of the materials often employed for the prevention of cross-pollination. As a result of a critical test of cotton fabrics made by Jenkin (**2**, p. 10), they were subsequently discarded in favour of vegetable parchment sleeves, which have proved highly successful at Aberystwyth. Given parchment of good quality, satisfactorily gummed, the single sleeves will stand considerable wind and rain. Double sleeves have been used satisfactorily to give greater strength.

The method was demonstrated on a pot plant, as all those in the field had been cut back. The supporting bamboo varies in length according to the type of plant being tested ; for ryegrass, fescue and timothy a 6 ft. cane is used, but others, such as *Phalaris arundinacea*, would probably need one 8 ft. long. Bamboo canes of suitable thickness have proved more useful than 1 × 1 inch Dahlia stakes. They are less cumbersome and much more flexible and durable in bad weather.

The cane is fixed into the soil conveniently near the plant and the inflorescences to be selfed, and fitted with cotton wool pads (fig. 1, A and B). The stems of the selected heads are also rolled in cotton wool so that its upper end comes within a few inches of the base of the lowest head to give the greatest possible room for elongation within the sleeve. The pad on the stems and that on the bamboo are then tied together with bast as in fig. 1, B. The sleeve is slipped over the stake and heads, and made secure at top and bottom over the cotton wool by means of four firm string ties each finished with three knots. The head of the sleeve also has an anchor tie to one of the nodes to prevent slipping and sagging (see figs. 2 and 3). The label is waterproof and has strengthened eyelet holes at both ends (see fig. 3) giving two ties. The writing on both outside and indoor labels is always done with a garden pencil.

If the exposed haulms are long, one or more bast supporting ties are made to the cane so that the heads are not pulled down into the cotton wool during boisterous weather.

When these sleeves were first tested wire coils were placed inside to keep them in shape. Experience has shown that they are not necessary with the sizes used (25 × 7 ins., and 28 × 8 ins.). Coils have the disadvantage that the inflorescences tend to become caught in them as their stems elongate and so become damaged.

Selfing by this method can be carried out by one person, but more conveniently by two. Where many plants are to be selfed it is advantageous to do all the preparation of the units beforehand. This enables the actual covering to be done much more rapidly, an important factor since it is best to leave the bagging until as reasonably near flowering as is compatible with safety.


FIG. 1

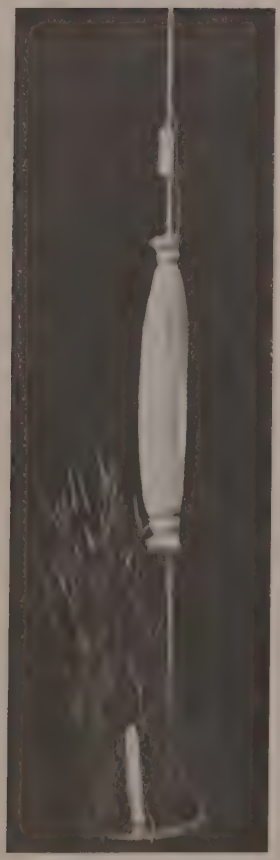

FIG. 2

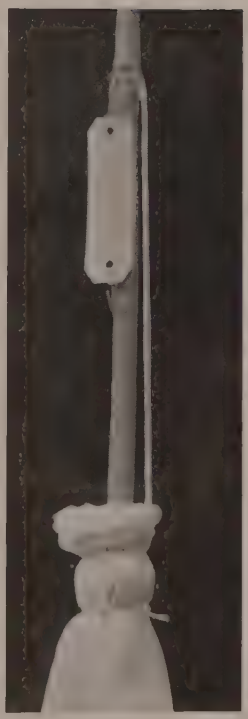

FIG. 3

POLLINATION NOTES:

| | | |
|---|---|---|
| P. Book No. | 66 | 21 |
| Experiment No. | | |
| Prov. Cross No. | | |
| Year | | |
| Female Parent | | |
| Method | | |
| Bagged | | |
| Emasculated | | |
| Male Parent | | |
| Harvested | | |

THRESHING RESULTS:

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inflorescences: | | | | | | | | | | | | | | | | | |
| Light Seed: | | | | | | | | | | | | | | | | | |
| Light-Heavy Seed: | | | | | | | | | | | | | | | | | |
| Heavy Seed: | | | | | | | | | | | | | | | | | |
| Total Emasculated: | | | | | | | | | | | | | | | | | |
| No. of Spkts. Used | | | | | | | | | | | | | | | | | |
| Percentage Take: | | | | | | | | | | | | | | | | | |

NOTES:

GERMINATION and SEEDLING RESULTS:

Box I. Seed Sown: Date:

Box II. Seed Sown: Date:

*Plate IV*

The specimen represents one page from a " P " book. These books are used and, like the " M " books, have been evolved at the Station for recording data in connexion with hydridization.

The number of the P book (66 in this case) is printed on the spine and front of the cover (see Plate 1, fig. 1). The 21 at the top right hand is the page number. A cross recorded on this page would therefore be referred to by its provisional cross number, that is *P* 66.21. The data can then be summarized on cards so that they are readily available, but if at any time some question arises with regard to the results as recorded on the cards, the reference to the original records is easy since the " P " reference number at once gives the number of the book and the page.

In the " germination and seedling results," the blank space provides room for an abbreviated description of seedling types such as " N. Gr." (= normal, green); " D. Gr." (= Dwarf, green), and so on, while in the columns are entered the numbers at various dates of examination. Where the seeds from a cross are too numerous for two boxes, a line can be drawn across midway to provide for three or four boxes.

*Plate V*

This specimen represents a page from an "M" book in which data concerning selfed units (or of male units if bagged before coming into flower) are recorded.

The reference number for this page would be that of the provisional line number = M101/97.

The pages of the P and M books are foolscap size (8 × 12.5 ins.), and they are ruled across with feint lines. The book covers are waterproof.

The provisional cross or line number is carried not only by the unit's label, but also by any seed and seedlings which may be obtained.

M. Book No. 101
Experiment No.
Prov. Line No.
Plant
Date Bagged
Method
Harvested

NOTES:

97

THRESHING RESULTS:

| | Spkts. or Cms. Enclosed | Flrts. per Spkt. or Cm. | Heavy Seeds |
|---|---|---|---|
| Loose Seed | | | |
| Inflce 1 | | | |
| " 2 | | | |
| " 3 | | | |
| " 4 | | | |
| " 5 | | | |
| " 6 | | | |
| " 7 | | | |
| " 8 | | | |
| " 9 | | | |
| " 10 | | | |
| " 11 | | | |
| " 12 | | | |
| " 13 | | | |
| " 14 | | | |
| " 15 | | | |
| " 16 | | | |
| " 17 | | | |
| " 18 | | | |
| " 19 | | | |
| " 20 | | | |
| TOTALS | | | |

Average Florets per Spikelet:
Total [Calculated] Florets:
Heavy Seed per Inflorescence:
Heavy Seed per 100 Spikelets:
Heavy Seed per 1000 Florets:
NOTES:

GERMINATION and SEEDLING TYPES:

Box. 1. Seed Sown: Date:

# SEED PRODUCTION OF THE POA SPECIES*

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[Translator: R. Peter Jones]

Only during the last decade has seed production of the *Poa* species in Sweden been sufficiently extensive to be of significance in the provision of the country's seed requirements. Before 1930 only occasional small plots were to be found, to be described rather as experimental plots. As at least two of the species of *Poa* are among the most important pasture grasses of Sweden, the increase of the seed production area is closely connected with an improvement in pasture cultivation in the country and the requirement of seed occasioned thereby. However, seed production of the *Poa* species acquired a more stable character when the plant breeder succeeded in producing new strains suitable for growing in Sweden, and for the distribution of which an indigenous seed production was an initial pre-requisite.

## Annual Requirement and Yield

Sweden's annual seed requirement of *Poa pratensis*, *P. trivialis* and *P. palustris* amounts according to Witte to at least 75-100, 10 and 5 tons respectively. It is difficult to furnish accurate information concerning the amount of seed produced in the country at present. On the average of the last six years according to data from the State seed exhibitions the amounts have been: *Poa pratensis*, 6,280 kg.; *P. palustris*, 5,760 kg. and *P. trivialis*, 2,650 kg. The following were the hectare yields on the average for the same years: *P. pratensis*, 423 kg., *P. palustris*, 714 kg., and *P. trivialis*, 363 kg.

Though the figures given for the year's seed production certainly are on the low side so far as they relate to the country's total seed production of the respective species, it is, however, clear that the amount of indigenous *P. pratensis* seed is still much too small to satisfy requirements and that only the production of seed of *P. palustris* is adequate.

That indigenous seed production of *P. pratensis*, which thus at present does not appear to satisfy more than approximately 10 per cent of the country's seed requirements, has not been conducted on a larger scale is due to a number of circumstances. This cultivation is, as already stated, of comparatively recent date, so that growers lack both practical and experimental experience of it. In addition, sowing, management and harvesting present certain difficulties. Although seed production of *P. pratensis* can never be conducted on a very large scale in Sweden—at present the requirement of indigenous seed necessitates an area of only 250-300 hectares—yet it

*From an Address at the Congress of the Association of Scandinavian Agricultural Research Workers at Ultuna, 1938, published in *Svensk Frötidning*, 7. 79-83. 1938.


FIG 1 :—A *Poa pratensis* type with intravaginal shoots.


FIG 2 :—A *Poa pratensis* type with extravaginal shoots.

FIG 3 :—Left : A *Poa pratensis* type with very few panicles.
Right : A type with good panicle formation.

FIG 4 :—Progeny of a sexual *Poa pratensis* plant. Great segregation.

is highly desirable that it should be increased at least to this area. What in particular speaks in favour of such an increase is that it is needed in order that the results of plant breeding may be fully utilized. How far one can conceive of a future export of *P. pratensis* seed which would occasion a further increase of the seed area it is difficult to predict. The points of view now set forth concerning the development of indigenous seed production of *P. pratensis* apply also to *P. trivialis*, although this species is of much less importance.

When one speaks of the breeding of meadow plants, one thinks more particularly of breeding for hay and pasture leys. But it is quite obvious that in the breeding of meadow plants it is essential that it should be possible to produce seed of the new strains without too much difficulty, so that the seed can be obtained at a price which growers can afford to pay. This fact should be borne in mind with pasture grasses in particular ; in working with them the plant breeder confines his attention almost exclusively to the vegetative part of the plant and is not greatly interested in the development of the fertile part. For the seed grower on the other hand the procuring of the formation of as many fertile shoots as possible is of primary importance. But he for his part must see that seed production does not change the valuable characters which a strain has acquired through breeding. In the breeding of the *Poa* species it should certainly be possible by suitable selection to do much to produce good seed production types without at the same time their value as good pasture strains being impaired. I hope in what follows to be able to give an example of this.

In dealing with seed formation and seed production of the species of *Poa* mentioned I shall consider first the most important of the three, *Poa pratensis*.

## Poa pratensis

In the year when it is sown this species never forms fertile shoots. During the following year panicle bearing shoots are formed and also from these usually a mixture of intravaginal, sterile shoots and extravaginal, likewise sterile, shoots. Certain types have only the former (see fig. 1) ; others only the latter shoot types (see fig. 2). The proportion between fertile and sterile shoots is strongly influenced *by the method of sowing, manuring*, and so on, but in a high degree also *by the strain*, with which I shall now deal. The types mentioned with few extravaginal shoots have frequently very luxuriant panicle formation, but owing to sparse shoot formation are almost valueless for use in pasture leys. As extreme forms in the other direction may be mentioned types I obtained from north Sweden, which, when grown at Weibullsholm, practically never formed panicles probably owing to the change in conditions of light (see fig. 3). Cases parallel to this are already known. Dr. Sylvén has mentioned previously (see Bulletin No. 21 in Herbage Publication Series) that certain Norrland types of *Festuca pratensis* form only few panicles when tested in south Sweden, and Agerberg has informed me that certain strains of *Festuca rubra* from south Sweden and Germany virtually do not come into panicle when grown in Luleå. It is of the greatest importance to be aware of these facts in seed production, particularly in a country like Sweden, where conditions of light vary so considerably

from south to north. We require a large number of strains of each cultivated plant to meet the needs of the different areas, and these should as far as possible be grown for seed *within* their areas of cultivation, in the first place to obtain a maximum panicle formation, and in the second place to prevent seed production exerting an unsuitable selective influence on the strains. Other types of *P. pratensis* collected have not formed panicles, but for quite a different reason, namely, owing to attack by *Epichloë typhina*. It is very remarkable that this disease has shown no tendency to spread but during every year has confined itself to the plants in which it entered.

The biotypes I have had in my material have also shown a great difference in stem formation at different ages. It is probable that a suitable selection for this character can do much to raise the yield and render it more certain in the older (2 to 3 year) seed leys, in which stem formation may frequently be the minimum.

I stated that the method of sowing has a marked influence on the first year's panicle formation in *P. pratensis*. If, for example, barley is used as a cereal nurse crop, development becomes so delayed that practically no panicles are formed the following year. We therefore sow in a nurse crop which ripens very early and shades but slightly, such as flax, or we sow in barley with red clover, when a hay cut is taken the first year. A sure method is to sow without a nurse crop, but this is relatively costly. As a fourth method, which has not yet been thoroughly tested, may be mentioned sowing the *P. pratensis* in winter cereals (winter rye) when it attains to such development the following year that it gives a satisfactory yield of seed the first harvest year. Which of the four methods is the most advantageous from the economic point of view has not yet been the subject of comparative testing. The result of such testing would also be dependent on the seed production centre, price of seed, etc. If the method of sowing in winter cereals proves reliable, it appears to me to have much to recommend it. Later, however, I shall deal with a totally different expedient which we might be able to use to expedite both germination and development of *P. pratensis*.

Manuring also is in a high degree responsible for panicle formation in *P. pratensis*. Panicle formation appears to be particularly sensitive to the way nitrogen is supplied both as regards time and quantity as the researches of G. Nilsson-Leissner and other investigators have shown.

In *P. pratensis* Müntzing first showed that seed formation at least in certain biotypes is apomictic, that is to say, seed is formed without previous fertilization. This has also been confirmed by the researches of Rancken, Åkerberg and Nissen. Certainly it has also been shown that pollen must be conveyed to the stigma in order that the seed primordium may develop into a seed, but here the pollen induces as a rule only seed formation and thus does not influence the appearance of the progeny which is completely maternal. Sometimes, however, there arise from the other plant deviating types deriving from seed formed sexually. The frequency of these deviating types may probably be influenced by many different factors. In 467 plants deriving from different biotypes I found 43 such aberrants. Besides the apomictic biotypes, purely sexual biotypes also appear in *P. pratensis*. Their

frequency in nature is rather low. Up to the present in a quite extensive material I have found only four, which on the basis of the appearance of the progeny have been characterized as sexual (see fig. 4).

For seed production the apomictic types are of course of the greatest value, because their characters remain unchanged in whatever way or however long they are grown for seed. To be sure, aberrants can arise as stated, but their frequency probably cannot be influenced to a material extent by the method of seed production employed. On the other hand, it is possible that aberrant frequency in certain cases might be increased if two strains of *P. pratensis* are grown too near one another. No general statement can be made as to the degree of isolation necessary for seed plots of *P. pratensis*, but it is probable that the distance between them need not be very great.

The sexual types within *P. pratensis* on the contrary have their great value for the breeder as via them he can combine characters of different strains and also thereby carry on a systematic breeding and not only a selection. But the concern of the breeder is to seek to obtain from the strains he produces apomictic types in order in that way to have them fixed in their characters for the future.

A large number of investigations have been carried out into the seed setting capacity of various types of *P. pratensis* in different surroundings (Nilsson, Åkerberg and Nissen). They have shown that seed setting in the florets of a panicle is very readily influenced by external conditions, but that this sensitiveness to the surroundings is to a great extent a strain character. The difference in seed setting determined in one and the same biotype in different surroundings appears in a high degree attributable to quantitative and qualitative pollen formation under the different conditions of the surroundings. Further, in certain cases physiological perturbations in the development of the seed may also supervene. Although much remains to be done to elucidate seed setting of *P. pratensis* in different surroundings, in the case of various biotypes investigations already conducted give a good indication as to what reliability in seed yield may be shown by different strains. Certain types exhibit a variation in seed setting from almost nil to the largest amount met with. Others may under exactly the same conditions show only slight and purely accidental variations. One has reason to expect that the former types will in seed production on a large scale in the face of the considerable variation in surroundings, conditioned by soil and climate, show greater fluctuations in seed yield than the latter. In breeding, by selecting strains less sensitive to the surroundings, an improvement and above all less variation in the yields of *P. pratensis* should be produced.

Pollen must then always be conveyed to the pistil in order that the seed primordium may develop into a seed in the apomictic types of *P. pratensis*. However, it is not necessary that this pollen should be taken from *P. pratensis* itself. According to experiments which I have conducted up to the present, pollen from *Poa alpina* appears to stimulate the formation of seed as well as pollen from *P. pratensis*. Most frequently the progenies from these "crosses" are maternal, that is to say, pure *P. pratensis*, but occasionally genuine hybrids appear. I think that using these hybrids

as the initial material it should be possible to obtain types with more rapid germination and development than pure *P. pratensis*. The hybrids show much more rapid germination than *P. pratensis*, a character which it would be highly desirable to be able to transmit to the latter, the slow germination of which is frequently a cause of poor establishment. Further, these hybrids reach the panicle-bearing stage much more quickly. Through back-crossing of the hybrids with *P. alpina* I have obtained plants which already in the year of planting out formed panicles and seed, which *P. pratensis* never does. The products of back crossing are, of course, not directly utilizable in practice, but through repeated crosses with *P. pratensis* is should probably be possible to obtain types combining rapid germination and development with the capacity for production and spreading which *P. pratensis* possesses. These types should not only facilitate seed production of *P. pratensis* but would also be of particular interest for pasture leys, as they would probably be able to assert themselves in a ley stand more rapidly than pure *P. pratensis*.

### Thousand-grain Weight in Poa pratensis

It might probably be of importance for seed control to know how greatly the thousand-grain weight varies among different strains of *P. pratensis*.

In a large number of biotypes from Weibullsholm of which I investigated the thousand-grain weight, this showed great variation from lowest 0.15-0.20 grm. to highest 0.60-0.65 grm. The largest number of biotypes had a 1000-grain weight between the limits 0.30 and 0.50 grm. A higher 1000-grain weight in a strain would probably entail the advantage from the seed production point of view that the seed would be easier to clean and free from weeds than a small seeded lot. Some of the Swedish bred strains have too a considerably higher 1000-grain weight than imported seed lots from America.

### Poa palustris

According to the investigations of Kiellander, *P. palustris* also appears generally to have apomictic seed formation, but within this species too sexual types are met with. However, *P. palustris* differs from *P. pratensis* in that its chromosome number is lower and does not vary so much. The apomictic types in *P. palustris* are of the same significance for seed production as the corresponding ones in *P. pratensis*.

Whether *P. palustris* exhibits the same variation and sensitiveness in relation to seed setting as *P. pratensis* has not yet been investigated. The hectare yields of seed appear, as already mentioned, to be considerably higher than in *P. pratensis*. Further, when sown in a cereal nurse crop it forms panicles relatively abundantly in the first year, so that from the point of view of seed production it is more profitable than *P. pratensis*. The greatest difficulty with *P. palustris* is to obtain a uniform stand, as in the first place the seed germinates very slowly, and in the second place it is very sensitive to depth of sowing. *P. palustris* is, however, of no great importance in meadow plant cultivation in Sweden. It is in the main used to some extent for long duration hay leys on peat soils.

### Poa trivialis

*P. trivialis* deviates in many ways from the two species mentioned in regard to seed formation. It appears to be purely sexual, but the question as to the extent to which this species is a self-fertilizer has not yet been investigated. The chromosome number is low, 2n = 14. When sown in a cereal nurse crop it also forms panicles abundantly in the first harvest year. But subsequently it forms no panicles. Seed can, therefore, be produced for only one year.

# REFLECTIONS CONCERNING NEW CROP VARIETIES

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## Introduction

Within recent years much has been written concerning the general ecology of grasslands and the adaptation of grassland constituents. Although the observed effects of ecological factors operating over long periods of time, as in the case of natural and semi-natural pastures, indicate the trends of natural adaptation to environment they do not provide an infallible guide to the agricultural conditions under which these adaptations will attain their greatest usefulness. Only rarely are the inherent ecological attributes of crop varieties directly studied in relation to a variety's maximum utility under the more or less artificially controlled environment of cultivation. In the present article it is therefore proposed firstly to compare the ecological units of the wild with their agricultural equivalents, and secondly to suggest possible means of increasing grassland production by making the fullest economic use of the available ecological peculiarities of new varieties.

## The Ecotype Concept and its Agricultural significance

The term *ecotype* was proposed by Turesson in 1922, and as an abstract concept it has since then invaded plant breeding literature. Particular ecotypes are seldom mentioned, the term generally being used to denote a population which, it is assumed, is specially adapted to its habitat. It is, however, curious that while the implications of the ecotype concept have been readily appreciated and have already considerably influenced plant breeding technique, the nature of the unit itself and its relationships to other units have received so little attention.

In the sense of Turesson an ecotype is a population which has become differentiated in response to the environmental conditions of its habitat. The occurrence of races of similar appearance in separate localities of similar environment is suggestive of the ecotypic fractionation of a larger population. However, it would be a misrepresentation of natural phenomena to regard all kinds of local differentiation as indicative of habitat differentiation. The conjunction of habitat and habitat type may have reference to some characters and not to other, perhaps more striking ones. The same ecotype therefore is not necessarily genetically uniform over its entire range. Even in respect of the ecotypic characters themselves populations are seldom clearly delimited, and diagnosis of an ecotype is largely dependent on the determination of the proportional representation of "indicator" characters. For example, in the Sea Plantains of Britain the distribution of growth-habit types results from the action of environmental factors such as grazing, exposure to high winds, etc. Growth-habit is therefore regarded as an ecotypic indicator character of diagnostic value.

Thus the ecotype *decumbens* is represented by populations where decumbent growth-forms predominate, and similarly *ascendens* by populations where ascending individuals are in the majority. It should be emphasized, however, that growth-habits form a continuous series ranging from the extreme decumbent to the extreme erect, and according to the prevailing habitat conditions different points on this series attain predominating frequencies, and impart individuality to populations without sharply delimiting them as ecotypes. Provided a sufficiency of varied habitats were available, the average growth-habit of populations would present a continuous ecological trend or *ecocline* to use Huxley's terminology. These considerations make it imperative to study both the spatial and ecological relationships of characters before concluding that a population represents an ecotype in the sense of Turesson.

Numerous examples of the occurrence of racial differentiation in contiguous valleys and even in one and the same valley, unaccompanied by discernible ecological differences are cited by Crampton in his monograph of the snails inhabiting Tahiti. It is extremely improbable that all these differentiated populations are specialized to different habitats. What is more likely is that chance differences in the frequencies of genes at the time the various populations were founded have influenced the ultimate population characters. Such predetermined differentiation is not ecotypic in the strict sense of the term as it apparently arises from the chance fractionation of a parent population. Because populations of this kind are often comparatively uniform genetically, and because their predominant characters are at least tolerant of the prevailing environment, they are valuable to the breeder.

It is also inadmissible to assume without experimental evidence that if a population is found to possess characters of demonstrable ecotypic significance, these characters are optimal for similar habitats elsewhere. For example, in coastal regions where Sea Plantains are more or less continuously distributed, size and growth-habit have been found to be controlled by environment. Inland, however, some relatively dwarf populations exist in isolated lowland habitats which, by analogy with similar habitats near the coast, might be expected to support large sized plants. But there is evidence to show that these inland habitats have been populated with local migrants from mountain localities where large size is absent. It would therefore almost certainly be incorrect to conclude that in such cases dwarf habit has been favoured at the *expense* of tall habit. After due regard is given to the probable genotypic limitations of the original migrants it would be equally inappropriate to use local distributional anomalies of this kind to discredit the ecological significance of the character concerned.

There are, moreover, widespread characters which affect all ecotypes occurring within their sphere of influence. For example, an anthocyanin leaf spot gives regional character to the Sea Plantain ecotypes occupying northern Europe and eastern North America.

It may not be far from the truth to say that amongst non-vegetatively reproducing plants a type's optimal environment is that in which seed reproduction reaches

its maximum expression. Nevertheless in most habitats preferential, as opposed to maximal, seed production must play a major role in establishing the predominant characteristics of populations. These characteristics, even when their ecotypic significance is unquestionable, might have little direct economic value. For instance, it is conceivable that a decumbent ecotype of *Lolium perenne* developed in response to prolonged grazing might be economically inferior, even in its own locality, to a more erect variety of greater vegetative vigour. Similarly, in a variety grown for its seed the environment of maximum reproduction is not invariably its optimal *economic* environment, e.g. the value of a barley variety is judged by its productivity and quality, not by yield alone. Since ecotypic specialization and economic utility do not always run parallel to each other the value of ecotypes to the plant breeder is more likely to lie in their usefulness as a source of material for the production of bred strains than as a direct supply of commercial seed. The established regional races, e.g. of *Phleum pratense* in Scotland and *Trifolium repens* in England, are the nearest agricultural equivalents of ecotypes. But differential cultural treatments and periodic reseeding within a region tend to interrupt or prevent the formation of a regional ecotype. The bred strain corresponds still less to the natural ecotype, representing as it does a comparatively uniform population which has been consciously selected to a preconceived standard and whose environmental preferences have to be later determined by trial. Undoubtedly ecological preferences determine the general distribution of crop plants, but they are not the ultimate determinants of a variety's usefulness. For instance, if the economic characters of a variety do not attain a prescribed standard in a habitat it is not, commercially speaking, fitted to this environment. Thus ecological attributes become subordinated to economic demands, and the gap between the ecotype and its agricultural equivalent is still further widened. It would therefore be unfortunate if the term ecotype were to be applied indiscriminately to categories of such different meaning and origin.

Notwithstanding the inconsistencies of the basis of assessing a population's fitness to its habitat, the concept of ecological control of plant distribution obviously retains its agricultural significance. But if the term ecotype were to be interpreted in its agricultural sense it would be deprived of much of its significance as a unit in a genecological classification of wild populations. In consequence, and to avoid the inappropriate use of the term ecotype in agricultural literature, the prefix *agro-* might with advantage be added to the ecological units of cultivation. This *agroecotype* would be described not in terms of its morphology but with reference to the cultural environment under which it may be expected to attain its usefulness, i.e. in terms of the general climatic, edaphic and biotic conditions and farming practice of such an agricultural environment. As far as herbage plants are concerned their cultural environments might be very broadly indicated by descriptive headings like upland-pasture, upland-pasture-hay, lowland-pasture, etc. A nomenclature of this kind could be applied conveniently to the main agroecotypic categories. Thus the description of a particular upland-pasture agroecotype might read as follows :

UPLAND-PASTURE, I.

*Climate*, northern insular, summer and winter temperature differences slight, rainfall 28 to 36 inches ;
*Soils*, poor mineral, winter water-table high ;
*Biotic environment*, bottom grass in closely grazed pastures ;
*Farming practice*, 4 to 6 years pasture, aerial competition detrimental, sow under grazing nurse crop, flowering July.

Different species possessing races which are useful under similar conditions would therefore have analogous agroecotypes. This is particularly likely to occur in herbage plants where varieties of unrelated species can be chosen to fulfil the same purpose. For instance, upland-pasture agroecotypes of *Cynosurus cristatus* and diploid *Phleum pratense* might be found to have practically identical descriptions. It is important to note, also, that an agroecotype may comprise more than one agricultural variety of the same species, where the varietal distinctions are based on economic or even arbitrary characters quite without ecological significance, e.g. Red and White Fyfe wheat. The variety and not the agroecotype is therefore the ultimate crop unit. Since some populations, especially populations of cross-fertilizing plants, are often indiscriminately referred to as strains or varieties it would seem advisable to adopt a single term such as *agrotype* for all agricultural populations which are placed on the market, whatever their degree of morphological distinctness. An account of the conditions under which these agrotypes reach their greatest agricultural utility, together with brief descriptions indicating their diagnostic and economic characteristics would be essential not only for assessing agroecotypic relationships but as a means of recording available crop plant material. The ever-increasing specialization of crop plants resulting from the efforts of plant breeders suggests that in the near future some such scheme of crop classification will be required for the guidance of farmers, merchants and plant breeders themselves.

## THE ECONOMIC UTILIZATION OF NEW HERBAGE VARIETIES

It may well be that in order to increase grassland production by the use of specialized varieties, specialized seeds mixtures and systems of grazing will have to be adopted. At the present time it is usual to regard new herbage varieties merely as components of multiple grass-species seeds mixtures. But there is no reason for assuming that they will attain their greatest usefulness either in the orthodox seeds mixture or in the customary all-the-year-round pasture. In theory a suitable plan of management for pastures composed of complicated seeds mixtures can easily be visualized. But in practice seasonal peculiarities and the needs of stock not infrequently make the strict adherence to a preconceived ideal a practical impossibility. In a dry spring, for instance, when grass is scarce, excessive grazing of pastures is unavoidable although it may be fully realized at the time that the treatment is detrimental to the grasses expected to produce fodder later in the season. A complicated seeds mixture thus obviously contributes to the difficulty of maintaining an effective system of pasture control.

The remedy then would seem to lie in the simplification of mixtures and the provision of pastures where only species and varieties of similar growth rhythm would be associated. In this respect we might imagine a sequence of specialized mixtures where all species in any one field develop simultaneously. Under such a system the over-grazing of early species would in no way interfere with the species relied on for later use. But even here interspecific competition and the possible effects of selective grazing would still be operative. Therefore, to reduce even more the variables which it is the object of management to control, the mixture might be further simplified and comprise only varieties of a single grass species. For example, a top- and bottom-grass variety of early cocksfoot for spring grazing, a ryegrass mixture for later, and a timothy mixture for midseason grazing. These in turn would be followed by the grazing of their aftermaths in successive order, or as occasion demanded. Such treatment should minimize the risk of a fodder shortage at critical times and might actually supply a greater annual bulk of herbage than an equal area of pasture arranged on orthodox lines.

Similarly, the advent of specialized varieties may in time influence the general methods of land reclamation. It may be as well to mention that there are here two distinct problems: the reclamation of open hill grazings, especially those at elevations above the limit of profitable arable cultivation, and the reconditioning of enclosed lands now in poor pasture. Until it is appreciated that many of the latter are, in their present deteriorated state, useless as arable land, or even for productive pasture, the importance of reconditioning will remain over-shadowed by hill-land reclamation, which appeals more to the popular imagination. Numerous methods of land improvement have been recommended, but the usefulness of any particular method depends largely on local circumstances. The use of the plough, however, is becoming increasingly advocated. Although on many upland farms, ploughing of the enclosed grassland still presents relatively few difficulties, considerations of finance, labour supply or climate make even temporary additions to the arable acreage impracticable. Therefore, under these circumstances renovation, to be economically successful, must avoid the customary interim period of rotational cropping.

A serious deficiency of the minerals essential for the growth of the valuable pasture plants is a common feature of degenerate pasture lands. Obviously the first consideration in a programme of renovation is to apply sufficient manure to ensure the establishment of the plants sown. But to attempt to raise the fertility of the top nine inches of soil to this level at one application frequently necessitates heavy initial expenditure. It would therefore seem to be advisable to spread the cost over a period of years by concentrating on the fertilization of the top few inches only. The subsequent ploughing down of an improved herbage would automatically fertilize the lower layers.

Renovation by stages of progressively more productive pastures, each stage growing under a minimum application of artificial manures, has economic possibilities provided some financial return is obtainable during the process. For the experiments being conducted by the Scottish Plant Breeding Station at their upland Sub-Station* three stages have been planned as follows:—

*Ainville Sub-Station is situated 12 miles S.W. of Edinburgh at an elevation of 900 feet.

Stage I, a pasture consisting of large-seeded annuals e.g. varieties of oats and wheat, capable of growth under the poor conditions of soil tilth so often encountered after old pasture has been ploughed.

Stage II, a predominantly *Trifolium repens* pasture, or soil-fertility raising phase. Special attention has been paid to grass varieties with a growth rhythm coincident with that of wild white clover in view of the fact that clover makes but slow growth in the spring at high altitudes and under conditions of low soil fertility.

Stage III, a long duration pasture comprising perennial species of high productivity. The use of grazing annuals as nurse crops in stages II and III has provided satisfactory grazing without injuring the establishment of the more delicate perennial species.

Ultimately it should be possible to link up these practical considerations with the somewhat more theoretical aspects of the problem previously discussed, by recording the ecological attributes of new varieties in terms of their usefulness in cultivation. There is no doubt that the introduction into commerce of specialized varieties has increased the opportunities for agronomic research. And until this research can make available to the farmer information concerning the cultural conditions under which new varieties may be expected to attain economic value, he, as Watson points out, "will be left to discover for himself, often by a costly series of trials and errors, the particular new varieties that constitute, for him, improvements on the old."

# GRASSLAND PANORAMA OF THE LA PLATA REGION*

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[Translator : G. M. Roseveare]

The La Plata region, with its vast areas of grassland adapted by Nature through the process of centuries to local climatic conditions, may be described as a new country for the agrostologist, one as yet hardly touched by systematic research. Comparison with other regions supplying the world market with animal products makes this clear. It will be understood that within the narrow limits of this Congress paper it is not possible to present a review of even the most important aspects of conditions in this region. From the outset, therefore, we must content ourselves with the consideration of certain sections which appear to the scientist to present typical characteristics. They may appropriately be termed a "panorama."

For the benefit of Congress members having European conceptions of grassland farming, it should be noted that in the La Plata region and its hinterland, from the subtropics in the north to the —even at midsummer—inhospitable lands of Tierra del Fuego in the south, stock is raised entirely in the open. The stall feeding of animals, and therewith the necessity for keeping stores of fodder, are of exceptional occurrence, as for example, on isolated dairy farms and more especially on the stud farms (cabañas). For this reason the various methods of fodder production and conservation, the growing of green feed, ensilage, and hay-curing (predominantly lucerne), in spite of their increased employment on progressive dairy farms, still represent a departure from general usage and are confined to certain localities. But here at once we encounter the markedly extensive character of farm organization in the region, an extensiveness which naturally varies within a wide range in accordance with proximity to the market and especially local climatic peculiarities.

In this connexion there may be mentioned, for example, the fact that in December, 1936, the Argentine Government passed a decree whereby the maximum size ranch rentable from the State in the Territories of Tierra del Fuego, Neuquen and La Pampa, which had been fixed in 1918 at ten thousand hectares, was raised to twenty thousand hectares per single ranch, because the farming of ten thousand hectares alone was uneconomic in those semi-arid regions. In such regions stocking is reckoned at approximately one sheep per twenty hectares. On the other hand, the fertile lands at the mouth of the La Plata river easily carry four to five sheep or 1 to 1.5 head of cattle per hectare on well managed ranches. In places where supplementary grazing is provided through the growing of forage crops (lucerne, green winter oats, etc.), the

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figures for stocking are even higher, the dairy farms in the vicinity of the great centres of consumption probably representing the highest degree of intensive farming at the present time.

The development of cattle raising to its present, often exemplary high position began with the introduction, not a hundred years ago, of wire fencing, which—in conjunction with a regulation of water supplies by means of turbines—created the necessary conditions for the triumphal progress of the valuable English meat breeds, principally Durhams and Herefords, and for valuable breeds of sheep for different purposes.

Upon this rough background let me now outline some "panoramic" views of undoubted interest for modern grassland research.

## Lucerne

In the first place the wide cultivation of lucerne in Argentina is worthy of note. Although its beginnings go back right into the eighteenth century during the days of the Spanish colonists, when lucerne, coming by the trade routes of those days over the cordilleras from the western part of the continent, first obtained a foothold in Mendoza, the rapid development of the present lucerne zone actually belongs to the last fifty years. This region comprises principally the west of the Province of Buenos Aires and bordering parts of the territory of La Pampa. The soil is light, often directly sand soil, having, however, a permeable subsoil in which the deep-rooting lucerne is able to find abundant supplies both of water and of lime (loess concretions). Noteworthy is the fact that the lucerne in these areas serves first and foremost for grazing, so that in the course of time a pasture type of lucerne, adapted to these circumstances, has been formed through the repeated cropping and the treading of the animals.

In addition to the already mentioned physiological peculiarities which adapt it to grazing, morphological differences in the form of coarser habit, more powerful stem formation and more creeping growth distinguish the type from the delicate-stalked and fine-leaved hay lucernes. Persistence in these soils, peculiarly suitable for growing lucerne, is now as ever satisfactory, although in some less favourable situations the plants are apt to deteriorate more rapidly, the reasons for which it is not possible to discuss more fully here. At all events the growing of lucerne in the Argentine Republic reached, in triumphantly rapid development, a total area of 8,703,270 hectares by the year 1918-19, thereby exceeding even the total for the United States of America. The retrogression which then set in increased more rapidly afterwards, and in 1928-29 the area reached the considerably lower level, since then stationary, of approximately five and a half million hectares. This falling-off is attributable principally to the world economic crisis. In consequence of the lower prices obtained for animal products, even the relatively low costs involved in growing lucerne on arable land became uneconomic, for which reason the border-line cases of profitable lucerne-growing in particular became eliminated. People simply returned to the more extensive form of land utilization, the grazing of the natural herbage. But

even so the cultivation of lucerne in the Argentine Republic represents a particularly remarkable form of grassland farming, both on account of its widely extended area, still great even to-day, and also on account of the form of its utilization, namely, grazing. For this reason I have purposely given it a foremost position in this summary review.

## Grassland Areas

As was briefly noted in the introduction, the grassland areas here are principally used for the extensive, continuous grazing of large herds of cattle and flocks of sheep. The horse, as a result of the increase in motor traffic, is dying out in comparison with former days. But even with this form of grazing, the first modest attempts of the Spaniards and Portuguese to cultivate arable land were enough to permeate the autochthonous steppe flora with weeds. This process, as is comprehensible, began in the vicinity of human habitations and even at the present day is principally confined to the neighbourhood of settlements. South European thistle species such as *Cynara cardunculus*, *Silybum marianum*, *Cirsium lanceolatum*, *Centaurea calcitrapa* and *C. melitensis* as well as *Xanthium spinosum* may be mentioned in the first place. The process which therewith set in, a gradual permeation of the grassland vegetation with European species, at first proceeded slowly, but during the last half century, in conjunction with the rapid extension of arable land cultivation, very much more rapidly. Not only through this process of "Europeanization," but also and probably still more through invasion by the hard grasses *Stipa papposa*, *S. hyalina*, *S. neesiana*, *S. charruana*, and also by certain steppe weeds, including various species of *Andropogon* and *Baccharis* and also *Eupatorium bunifolium* and *Veronica nudiflora*—to mention a few only of the more frequent steppe weeds in Uruguay—a deterioration of the natural sward has set in. Details as to the course of this process in Uruguay may be found in G. E. Spangenberg's article : " Rules to be observed in the improvement of the natural pastures of Uruguay," *Rev. Fac. Agron. Montevideo.* 3. 311-402. 1930. In the case of the Argentine Republic reference should be made in the first place to the various articles, certainly of a more botanical nature, published by Lorenzo Parodi.

## Mineral Deficiency and Osteomalacia

A further contribution to the deterioration of the sward is made by the recently discovered impoverishment of the soils in lime phosphates. The process is mentioned here purely in connexion with the continually increasing number of cases of osteomalacia occurring in the phosphate-deficient regions, apart from any other considerations such as, for example, the absence of legumes or sacrifice of productivity. It is not only that there has been — since the Spanish conquerors four centuries ago introduced European domestic animals—a continual withdrawal of the mineral substances requisite for the skeleton structure of the land, without the making of any corresponding restoration, but there has also been an intensification of this process through the exporting of dried meat begun early in the nineteenth century. With the subsequent rise of the frozen meat industry, this exploitation and impoverishment of the soil assumed so rapid a pace that the consequences are now clearly visible in the La Plata lands, as in all other parts of the world from which meat is exported. We have

here one of the great overseas grassland problems, the solution of which is becoming an ever more urgent task for our generation. As under the extensive form of farming carried on here a statistical calculation of the amount of minerals to be restored is from the very outset impossible, an attempt is being made to neutralize these deficiency symptoms by rations of lime fodder containing phosphates. It cannot as yet be said whether by this means alone a conclusive solution can be found in the case of the poorer soils of the hinterland, where on the sloping, thin-crusted land, particularly liable to leaching, mineral deficiency phenomena are especially marked. The problem becomes, however, the more urgent, especially for the poor soils of the peripheral grazing districts of the La Plata basin (in any case poorly stocked), because the calcium phosphate deficiency results in a great lowering of the fertility index. In definite osteomalacia regions this, for cattle, is in extreme cases 30 to 40 per cent, as against 80 to 90 per cent on good pasture land.

## Intensive Dairy Farming

As regards the present position of grassland utilization, the brief reference already made to the more intensive farming necessary on the dairy farms requires some amplification. As dairy farming involves continuous grazing, provision has to be made both for the winter period when growth ceases and also for the height of summer when there is a scarcity of feed. Apart from the already mentioned special case of the lucerne area, provision has been made for grazing in both these periods. In winter it is principally the four European cereals which are widely grown as herbage. For this purpose oats are undoubtedly of most importance. In addition to *Avena sativa* I should like to mention in particular *Avena byzantina* (including the valuable La Estanzuela bred strain 1095a), which on account of its abundant tillering and creeping growth is often preferred. Rye takes second place ; it is successfully grown on the sandy soils of the Argentine Republic in particular. Forage barley is also sown for this purpose, although it does not resist grazing as well as oats. Recently wheat has also been used, but the right choice of varieties and very early sowing are necessary conditions of success. As in all these cases it is possible to obtain a grain crop in addition to the winter green fodder, this use of the cereal grasses may be described as a successful development under the conditions of this region. The use of other grasses, as, for example, *Lolium multiflorum* and *Bromus unioloides* is, on the other hand, less common, principally because the height of their development is not reached until late in the winter. The growing of suitable winter legumes at the same time is still at the experimental stage. For the period of midsummer fodder shortage large areas of Sudan grass are now grown. The breeding of types practically free of hydrocyanic acid, on which successful work is in progress at La Estanzuela, may in the near future open up still wider areas for the sowing of this valuable forage grass. Other sorghum species, including for the last few years the North American variety "Grohoma," and fodder maize also are sown for these purposes, whereby especial importance for ensilage purposes is attached to the locust-resistant bitter maize.*

*[See *Herb. Abstr.* 8. Abs. 2057. 1938.]

### Peripheral Regions

In the peripheral regions economic considerations enforce the greatest degree of extensiveness in farm organization, as has already been shown by the previously mentioned example of the doubling of the size of the ranches in some districts by the Argentine Government. These gigantic ranches, which always lack the corrective influence of human labour and often enough cover more than 100,000 hectares, represent the extreme cases of the extensive grazing farms natural to the region. Stock raising takes the form of cattle and sheep raising, so far as this is possible; in the areas further north, interspersed with forest, cattle raising predominates.

Extremes meet! On penetrating further into the illimitable forest regions of the northern La Plata hinterland one encounters—in Argentina, Paraguay and South Brazil alike—settlements of small colonists in the primeval forest, who are largely relegated to a state of autarchy on account of the isolation of their holdings. But as colonists of European origin are disinclined to give up using a valuable form of alimentation such as milk, their endeavour, as soon as they have cleared the primeval forest giants, is to create a modest area of grassland for the feeding of a few milk cows. Pasture of this kind has to be sown and carefully maintained in continual conflict with the luxuriant, aggressive primeval forest vegetation. Thus one finds intensive small farming in the midst of the illimitable stretches of the South American virgin forest. In the meantime, however, the problem may be considered as fundamentally solved. By planting tillers of various tried and proved grasses such as *Stenotaphrum* sp., *Pennisetum purpureum* and especially *P. clandestinum*, and sowing *Melinis minutiflora* and *Hyparrhenia rufa* it is possible to establish such pastures.

A longitudinal and a cross section of the present grassland conditions of the La Plata region! And if at the outset I remarked that this region presents virgin country for grassland research, it should be noted in conclusion that the first systematic work undertaken with a view to solving these and cognate problems in their relation to national economy was that of the small State of Uruguay. All efforts in this direction have been centralized in the Commission appointed in May 1935, by the Minister for Agriculture, Dr. César G. Gutierrez. A report on the Commission's programme has been published in *Herb. Rev.* 4. 78-81. 1936.

# THE GERMAN SOYBEAN PROBLEM

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[Translated from German by G. M. Roseveare]

## Manchuria, The Home of the Cultivated Soybean

Two groups of species may be distinguished in the genus *Soja*. To the tropical group belong the wild species *Soja javanica*, *S. tomentosa* and *S. pentaphylla* (Java, the Philippine Islands, India etc.), to the temperate group the wild species *S. ussuriensis*, the semi-cultivated *S. gracilis*, and the cultivated *S. hispida*. The Indian group of species, having very high warmth requirements and characterized by an unusually long period of vegetation, differs considerably from the less exacting Manchurian group. It is not known whether the two groups have a common ancestral form.

The parent species of *Soja hispida*, the cultivated plant distributed over all parts of the world, is the delicate-stemmed, twining, small-podded and small-grained *Soja ussuriensis* growing wild in the north-east of Manchuria ; the hill country between Ussuri and Sungari is the home and principal area of distribution of this parent species, which is found wild in many parts of Manchuria and Japan.

The semi-cultivated species, *Soja gracilis*, of which two hundred varieties are known in Manchuria, occupies an intermediate position between *Soja ussuriensis* and *S. hispida* ; this species hybrid with medium-sized pods and grains exhibits both twining and erect forms. The large-podded and large-grained *Soja hispida* is very rich in varieties, races and biotypes ; in consequence of the unusual number of its forms and types of structure this cultivated plant has been able to occupy wide areas in every part of the world. The parent species and both the derivatives in the Manchurian group have in the diploid phase $20 + 20 = 40$ chromosomes. The chromosome number of the Indian group, for which probably a distinct cultivated species *Soja indica* is to be assumed, has not yet been studied.

## Monsoon Climate, the Original Soybean Climate

The home of the soybean is the East Asiatic region between 130° and 134° east and between 46° and 48° north. As vigour and productivity prove, the north-east Manchurian climate is very favourable for the soybean. The boreal monsoon climate with its great warmth in summer, its heavy summer rainfall and the high degree of humidity in summer is the original and optimal climate for all the *Soja* species. A fine winter of dry cold is followed, after a short transitional period, by a moist, hot summer, particularly beneficial for this warmth-loving plant. High temperatures of over 22°C. in July, much rainfall in July and August, and a water vapour atmosphere, rich in blue-violet rays, distinguish the soybean climate. The soybean is a boreal monsoon constitution (Merkenschlager, **9**), which has great requirements in

**Table 1. Differences in the temperature and precipitation of localities in Manchuria and Germany.**

| Place | Latitude | Average mean temperature in degrees Centigrade | | | | | Precipitation in mm. |
|---|---|---|---|---|---|---|---|
| | | May | June | July | August | September | May to September |
| Mukden | 41° 48' | 15.1 | 21.4 | 24.4 | 23.3 | 16.7 | 510 |
| Harbin | 45° 45' | 13.8 | 19.7 | 23.1 | 21.4 | 14.3 | 441 |
| Blagovyeshchensk | 50° 16' | 10.5 | 17.4 | 21.2 | 18.2 | 12.1 | 439 |
| Freiburg | 48° 00' | 13.9 | 17.4 | 19.2 | 18.6 | 15.1 | 465 |
| Ludwigshafen | 49° 30' | 14.6 | 18.0 | 19.6 | 18.9 | 15.3 | 314 |
| Bonn | 50° 45' | 13.3 | 16.2 | 18.0 | 17.6 | 14.6 | 312 |

**Table 2. Comparison of the total warmth of localities in Manchuria and Germany.**

| Place | Latitude | Mean total warmth during the vegetation months, degrees C. | | | | | Total. |
|---|---|---|---|---|---|---|---|
| | | May | June | July | August | September | |
| | | 31 days | 30 days | 31 days | 31 days | 30 days | 153 days |
| Harbin | 45° 45' | 427.8 | 591.0 | 716.1 | 663.4 | 429.0 | 2827.3 |
| Zizikar | 47° 21' | 421.6 | 591.0 | 722.3 | 663.4 | 408.0 | 2806.3 |
| Ludwigshafen | 49° 30' | 452.6 | 540.0 | 607.6 | 585.9 | 459.0 | 2645.1 |
| Bonn | 50° 45' | 412.3 | 486.0 | 558.0 | 545.6 | 438.0 | 2439.9 |
| Blagovyeshchensk | 50° 16' | 325.5 | 522.0 | 657.2 | 564.2 | 363.0 | 2431.9 |
| Taipiulin | 44° 33' | 325.5 | 474.0 | 613.8 | 595.2 | 363.0 | 2371.5 |

**Table 3. Comparison of 1934 (a good soybean year) and 1936 (a bad soybean year) at Bonn.**

| | Year | May | June | July | August | Sept. | Total |
|---|---|---|---|---|---|---|---|
| | | 31 days | 30 days | 31 days | 31 days | 30 days | |
| Aver. mean temp. in °C. | 1934 | 13.7 | 15.7 | 19.4 | 18.3 | 18.2 | — |
| | 1936 | 12.9 | 15.5 | 17.8 | 15.1 | 14.8 | — |
| Total warmth in °C. ..... | 1934 | 424.7 | 471.0 | 601.4 | 567.3 | 546.0 | 2610.4°C. |
| | 1936 | 399.9 | 465.0 | 551.8 | 468.1 | 444.0 | 2328.8°C. |
| Precipitation in mm. ..... | 1934 | 38 | 120 | 42 | 44 | 21 | 265 mm. |
| | 1936 | 16 | 95 | 67 | 111 | 39 | 328 mm. |

warmth, soil moisture, air humidity and light. In spite of its northern home the soybean is a short-day plant ; it is well known that in the long-day zone plants with short-day tendencies are found, even although, in general, plants of the temperate zone are of a long-day and those of the tropical zone of a short-day character. It is not convincing to conclude from manner of reaction to short day that the Manchurian soybean is descended from a tropical ancestral species.

### Difference Between the Climates of Germany and Manchuria

The climate of Germany is temperate, maritime on the North Sea, continental in the east and south. The warmest regions are the lowlands of the Upper Rhine, the valleys of the Main, Neckar and Mosel, and the depression of south-west Germany ; but none of these approach the warmth and moisture of the Manchurian summer in any way. The 19°C. July isotherm corresponds approximately with the line of the Main ; the summer temperature rises slightly from west to east, the Baltic coast is warmer in July than the North Sea coast (17°, 16°C.). Clouding and precipitation increase from the interior towards the coast and with altitude. It is thus seen that the moisture conditions of the German maritime climatic regions are good for the soybean, but that the conditions of warmth are unfavourable ; while in the regions of continental climate the conditions of warmth are good and humidity is insufficient. It is not possible here to enter into a detailed consideration of the climatic differences between Manchuria and Germany. In that country the monsoon is everywhere the decisive climatic factor ; in this there is a climate varying greatly in accordance with proximity to the sea, whether more or less under Atlantic or continental influence.

The soybean thrives not only in the Manchurian zones of great summer heat and summer moisture, but also in the border regions having less favourable conditions. If the figures for Blagovyeshchensk are compared with those for Germany, it is seen that the differences are actually not very great (Table 1). It is, however, quite

possible to grow soybeans in this northern zone, for this warmth-requiring plant will ripen in any region in which a five-month period of vegetation prevails, in which a total amount of warmth of 2,400 C. is attained from May to September and the precipitation amounts to 300 mm. For the north of Manchuria and the bordering Russian district there are naturally special varieties for which these conditions are optimal.

Data on warmth requirements and the specially favourable distribution of rainfall are given in Table 3.

Table 2 shows that there are localities in Germany with an adequate amount of warmth.

### Fifteen Years of Breeding Produces German Varieties

Theoretical considerations and variety trials alike establish the fact that neither Manchurian soybeans nor those from other regions (the United States of America, Japan, China, Australia, the south-east of Europe, France, England) can find optimal conditions or thrive normally in Germany. The soybean problem is thus first and foremost a problem of breeding. Only when new varieties have been obtained can cultural experiments be undertaken.

Through breeding in Germany (Riede, **10, 11**) there have been obtained—by years of selection and crossing, continuous selection of individuals and descendants, selection of mutants and growing in bulk, and combination and transgression breeding—a number of adapted varieties, four of which, after a three-year test, have been awarded the title of "pedigree strains." With these strains, also, extensive cultural trials have been carried out, so that reliable methods of cultivation are now known and nothing more stands in the way of the cultivation of the crop.

The aim of the German plant breeder now, as is natural, is to produce varieties which shall give still better and more reliable yields, which shall have a still higher protein and fat content, shall be resistant to pests, parasites, viruses and unfavourable weather conditions, shall be good converters of fertilizers, require as little cultural and harvesting labour as possible, permit harvesting and threshing without loss, have moderate warmth and moisture requirements, shall develop more rapidly, flower and ripen early, and which shall be in every respect superior to the present good varieties. Special attention is being paid to rapidity of growth, rapid early development, rapid flowering and rapid ripening. It is not morphologically, but physiologically governed earliness that is desired ; tall, well-branched and productive varieties with short periods of vegetative and reproductive development and more modest requirements in regard to warmth and moisture.

All valuable distinctions and characters are composite characters which depend upon numerous independent factors working together. There is of course no obstacle to a union of these polymeric characters.

The constantly increasing virus diseases are making themselves felt to a particularly unpleasant degree. Many biotypes possess hereditary tolerance in regard to these viruses, but few lines exhibit hereditary immunity.

The artificial pollination required for the production of new biotypes is not very

difficult, although, on account of the small size of the flowers and the very early self-pollination, skill, practice and experience are necessary for success. In the $F_1$ generation, too, difficulties may arise, as it is not rare for the hybrid plants to ripen very much later than the parents (dominant factors for lateness working together) and there is a risk of full maturity not being reached. The $F_1$ plants are also frequently very badly diseased by virus, through the conjunction of different viruses or through dominant factors for susceptibility working together ; in the $F_2$ generation, however, early and healthy individuals are segregated.

The breeding of a grain soybean especially suitable for human consumption is a foremost consideration ; and in addition, work is being done on the development of a productive and rapidly growing soybean for ensilage, to give an average green weight of 400 dz. per hectare with a high protein content.

Although many desiderata are still wanting, it must be emphasized that the four bred strains certified in 1937, namely, Dieckmann's Black No. 11, Dieckmann's Green-yellow No. 18, Delitzsch Black and Giessen Black, are entirely suitable for present needs. They are all medium early, that is to say, fully ripe in September or October in accordance with region, situation, weather and cultural technique. The victor in many years' trials, Dieckmann's Black Soybean No. 11, is large-grained ; all the others are medium large-grained.

## Long Term Experiments Elucidate Cultural Technique

Once the fundamental problem, that of variety, has been solved, cultural technique with all its details of sowing, cultivation and harvesting must be studied. Experiments conducted for many years in every part and under the greatest variety of conditions have led to the formulation of certain procedures which may be regarded as correct. As in the case of every other crop plant, it is not possible to give any generally valid rules : every grower must act in accordance with his own particular conditions and collect his own experience if he is eventually to master the growing of soybeans (**3, 6, 12**).

*Rotation.* Oats, lupins, peas, vetch and sunflowers are unsuitable crops for preceding soybeans. On light soils the soybean thrives best after roots, on better soils after cereals. After the soybean, itself an excellent forerunner which leaves the soil in a good state of fertility, in a good physical, chemical and biological condition, it is best to grow a cereal (winter wheat). Where soybeans are grown for the first time they may occupy the ground for two successive years.

*Soil.* Loamy sand and sandy loam are preferred. It is essential that the soil shall be in a good state of culture and have a normal humus content. Shallow-bottomed soils, cold, wet soils, hard, crusting clay soils and sterile sand are all unsuitable. Tilth must be as for turnips, for only in a loose, granulated soil can the soybean thrive, with its slow early growth, high soil air requirements and its liability to be suppressed by weeds.

*Manuring, inoculation.* The soybean prefers a neutral soil, although it does well also when reaction ranges from pH 6.6. to 7.2. Deterioration in growth is slight

under alkaline conditions (pH 8), greater under acid conditions (pH 5), so that a suitable reaction must be ensured through liming. It is obvious that an adequate application of potassium and phosphoric acid is necessary, 80 kg. $K_2O$ per hectare, 60 kg. $P_2O_5$. Sulphate of potash and magnesia and basic slag have been found especially sucessful. A small quantity of nitrogen (20 kg. per hectare) in the form of saltpetre will be necessary only on light soils. The nitrogen requirements of the soybean should as a rule be covered by nodule nitrogen ; for this reason it is necessary to inoculate the seed with some *radicicola* inoculum (for example, soybean "radicin.") No too urgent warning can be given against the application of a nitrogenous fertilizer to rich soils ; retarded maturity and endangered harvest are the consequences.

*Sowing.* Sowing should not be done until the soil has dried and become sufficiently warm, the usual time being the end of April or the beginning of May. Seed in perfect condition and of the correct variety must—after the best of soil preparation and suitable inoculation—be sown in shallow drills with a normal driller (seed rolled in, 40 to 50 cm. drills, seeding rate 80 kg. per hectare). Drilling has proved superior to dibbling. In the case of medium ripe varieties, the planting distance should be 500 sq. cm. (50 × 10, for which reason hoeing must be done in June if the stand is too dense).

*Cultivation.* The soybean can be grown only in a field free of weeds. Hoeing is of the greatest importance for this plant, with its special air and light requirements. Harrowing seven days after sowing and repeated machine and hand hoeing are indispensable. The germinating seed must be protected from birds and the growing crop from game : pigeons, pheasants, hares, rabbits and mice are serious enemies of the soybean.

*Harvesting.* Full maturity is reached at approximately the end of September. Ripening can be hastened by a heavy application of KP, by choice of a light soil, by a warm, dry, sunny situation and by refraining from using a nitrogenous fertilizer. Cutting (by means of a hay mower, short scythe or pasture knife) is not done until the leaves fall ; skilful piling on racks (Swedish fencing) ensures complete drying and after-ripening. If it is necessary to put the crop under cover, this should be done only in an airy Dutch barn. Threshing is done with a normal threshing machine (number of revolutions reduced) after a period of frost has set in. The beans must be dried in thin layers on well ventilated wooden floors before they are placed in sacks. Special attention is drawn to the risk of the beans becoming mouldy and rotting.

All experience shows that the soybean cannot bear any neglect of tillage or cultivation, to which it responds with retarded growth and poor yield. Failure follows when the soybean is treated with any lack of understanding and skill. Incorrect manuring, unsatisfactory seed, unsuitable inoculation, poor cultivation, careless harvesting and drying lead inevitably to failure. The growing of soybeans should not be undertaken in severe climates, cool, humid, foggy situations or in shallow, gravelly, humus-deficient, wet soils.

## Experiments and Observations indicate the Soybean Regions

The fact that the soybean is to-day a world market plant in unlimited demand is largely due to the achievements of German research and German industry. Germany will certainly always import a large quantity of soybeans (Woertge, **16**), at the present time approximately 500,000 tons annually, from Manchuria, south-eastern Europe, etc.; but nevertheless the growing of soybeans in Germany will increase from year to year now that successful results in breeding and cultural technique have been achieved. Soybean growing on contract, with guaranteed sales and price (RM. 46 per dz.) is being taken up by peasants and farmers, and horticultural small holders also are taking part in the extension of the soybean area.

The growing of soybeans for grain in Germany should take place only in those districts which fulfil their requirements; these districts and islands may readily be found by means of meteorological and phenological reports and maps.

Warmth is the most important factor in the growing of soybeans, for which reason the 19°C. July isotherm (Mainz-Main frontier — Silesian plain) and the 18°C. July isotherm (Bonn-Berlin-Lyck) are indicated.

Especially good soybean regions are those in which the 20°C. period — that is to say, the period between the first and last occurrence of a mean temperature of 20°C. — lasts for 100 days (Mannheim-Ludwigshafen), 90 days (Leeheim-Oppenheim-Worms-Frankenthal-Speyer) or 80 days (Friedberg-Hanau-Aschaffenburg-Frankfurt-Wiesbaden-Bingen-Darmstadt-Dürkheim-Germerscheim-Landau-Karlsruhe-Lauterburg-Friedrichshafen). Regions with a 20°C. period of 20, 30, 40 or 50 days only are unfavourable.

Conclusions may be similarly drawn from the period between the first and last occurrence of a mean day temperature of 15°C. Very favourable 15°C. period, 160 days: Worms-Frankenthal-Mannheim-Ludwigshafen. Favourable 15°C. period, 150 days: Friedberg-Frankfurt-Bingen-Kreuznach-Alzey-Gross Gerau-Speyer-Karlsruhe. Still favourable, 140 days: Wöllsheim-Kaiserslautern-Neunkirchen-Dürkheim-Landau and Aschaffenburg-Bensheim-Heidelberg-Bruchsal-Durlach.

In considering precipitation, it is the regions of low rainfall that must be regarded as suitable for soybean cultivation. Good soybean localities are, for example, those with a rainfall of 435 to 500 mm.; rain shadow zones of the Harz, Thuringian valleys, the Magdeburg plain, northern Rhenish Hessia, the north of the Palatinate Rhenish plain, the Oder marsh, the Oder valley. Regions of 500 to 600 mm. rainfall are also suitable: the plain between Eifel and Ville, the lower Ahr valley, Rhenish Hessia, the upper Rhenish plain as far as Speyer, Wetterau as far as the Main valley, parts of Lower Franconia, Middle Franconia and Danube, the Dresden basin, basins in the south and west of Germany, Maifeld. Regions with an annual rainfall of 600 to 700 mm. are suitable for soybean cultivation only if they are also very warm.

The soybean naturally cannot grow at high altitudes with a severe climate, and the map of physical conditions must therefore be consulted before the culture is undertaken.

Of Engelbrecht's agricultural districts (**2**) the following are capable of growing

soybeans: zone of light soils from Kreuzberg to Sprottau, fertile plains left of the Oder (Grottkau-Liegnitz-Bunzlau), the south and east of the sandy Mark, the land between the Elster and the Elbe, the dry region east and south of the Harz, the dry southern region of the Upper Rhine plain (Lörrach-Kehl), the northern part of the upper Rhine plain (Karlsruhe-Bergzabern-Mainz-Kreuznach), the land along the middle Rhine and the Mosel, the sugar beet district left of the lower Rhine and the strip on the right bank of the Rhine from Bonn-Düren-Krefeld, the barley region of Mainfranken (Würzburg-Kitzingen), the Upper Franconian barley region (Bamberg-Fochheim-Schwabach), the barley region on the upper Neckar, the barley zone from Regensburg to Passau.

By means of Busch's work also (**1**) it may be determined whether a given place is suitable for soybean cultivation. Of the agricultural zones into which Busch divides Germany, the root-cereal-growing zones are especially suitable for soybeans: the Rhine country from Breisach to Mainz, Rhenish Palatinate, the Nahe valley, the Mosel valley, the Ahr valley, the Neuwied basin and the Cologne basin, the Neckar valley, the Main valley, the central German plain, the Vienna basin, the Breslau district. Soybeans may be grown in a considerable part of the cereal-root zones: the Bamberg-Erlangen region, the Regensburg-Straubing-Pfarrkirchen zone, Thuringia (Erfurt-Langensalza-Gotha-Zeitz), Saxony (the northern Elbe valley as far as Pirna), the Kurmark (Jüterbog-Luckenwalde-Teltow), the Oder region, the Oder marsh, the Netze region, Silesia. The forage crop, forage-cereal and cereal-forage zones are unsuitable for grain soybean cultivation.

Data concerning the entry of spring give an indication of suitability, or otherwise, for soybean cultivation. April 22: the Rhenish plain, the Mosel valley, the Neckar valley, the lower course of the Main. April 29: Saarpfalz, Mainfranken, the Danube valley (Regensburg-Passau-Vienna), the region Weimar-Eckersberga-Querfurt- Erlangen-Nuremburg, the Elbe valley by Meissen, Leipzig, Oberbarnim. May 6: Saxony-Anhalt, Silesia.

The early threshing zones are especially suitable for the growing of grain soybeans. According to Härle's maps (**4**), the winter rye-harvest regions correspond well with the soybean regions. In districts in which rye is ripe as early as July 10 to 16, conditions are particularly favourable for the growing of soybeans. The second zone, in which the rye harvest takes place between July 17 and 23, is in part capable of growing soybeans, while in the districts in which winter rye is harvested between July 24 and 30 soybeans can be grown for grain only in exceptional cases. The regions of late threshing are out of the question.

Härle's phenological tables (**4**) may also be used for ascertaining the possibility of soybean cultivation; the duration of ripening in winter rye (period between the beginning of flowering and harvest), which in Germany ranges between 38.6 to 65 days, should last from 40 to 50 days in good soybean localities.

| | | Days |
|---|---|---|
| 1. Sub-Sarmatian region: | Wohlau | 38.6 |
| | Liegnitz | 41.7 |

| | | Days |
|---|---|---|
| | Görlitz | 43.0 |
| | Breslau | 43.6 |
| | Döbeln | 54.4 |
| 2. Rhenish region : | Tübingen | 44.0 |
| | Darmstadt | 49.0 |
| 3. Swabian-Bavarian plateau : | Regensburg | 40.0 |
| | Pfaffenhofen | 45.0 |
| 4. Mountain and hill country : | Nuremberg | 43.0 |
| | Kreuzburg | 44.0 |
| 5. North Atlantic region : | Cologne | 46.6 |
| | Siegburg | 50.0 |
| 6. Baltic region : | Neustettin | 40.0 |
| | Greifenberg | 44.3 |

In the above six regions of vegetation the following districts are capable of growing soybeans :

Lausitz, Silesian plain, Thuringia-Saxony, central East Germany, middle Rhine-Mosel, upper Rhine, Mainz basin, Neckar, Danube, upper Main-Regnitz basin, Cologne basin.

Soybean islands may be found in many other parts. Although the duration of maturity in rye is no sure criterion for the possibility of soybean cultivation, it generally gives a good indication : those places in which the ripening of rye is very lengthy are unsuitable, as for example Schleiz (60.6) and Stadtsteinach (61.4).

Experiments and trials indicate that the warm parts of the following Regional Peasant Associations' lands may be used for soybean cultivation : Baden, Saarpfalz, Hessen-Nassau, Rhineland, Württemberg, Bavaria, Silesia, Kurmark, Saxon-Altenburg, Thuringia, Saxon-Anhalt, Hanover-Brunswick, and in addition the regions Lower Danube, Upper Danube, Styria, Salzburg and Burgenland. In the lands of the other Peasant Associations (East Prussia, Pomerania, Mecklenburg, Schleswig-Holstein, Weser-Ems, Westphalia, Kurhessen), only specially favoured small regions are suitable for soybean grain production.

## Vernalization, Planting Out, and Intercropping

The soybean is one of the short-day plants which respond with hastened development to a reduction in length of day. The short-day manner of reaction is present to a more or less marked degree in nearly all varieties. In the long-day zone, long-day reaction or neutral behaviour is naturally better; an attempt is therefore being made to produce neutral types or long-day types with good performance characters. Certainly the long-day reaction character is not of decisive importance ; all the long-day lines hitherto found are useless. When it is remembered that the home and principal area of cultivation of this short-day plant are situated in the long-day zone, it will be conceded that the manner of reaction cannot be decisive, although this

character plays a more important part in borderline regions. Length of day experiments (**13, 14, 15**) all show that stimulation by short day induces early flowering and ripening—at the cost of growth vigour and yield, it is true. An after-effect in the following generations, such as is referred to by Volk (**15**), never occurred in my experiments. For practical growing purposes stimulation through short day is of no value ; rearing in nursery beds, short-day stimulation by covering, and finally transplanting into the field would be an impossible procedure for the farmer.

Short-day reaction may be obtained also by early sowing (March to the beginning of April) ; unfortunately the other important factor for vernalization, warmth, is considerably lacking under early sowing. Vernalization of the germinated seed by means of warmth and darkening has been attempted repeatedly ; this process is of no practical value for the cultivation of soybeans.

It is clear that in the case of a plant which is to be grown in a borderline region, or even in a region with a different climate, everything possible must be done to induce a hastening of development : the selection of early types ; breeding of new early types by hybridization ; vernalization of the seed by means of warmth and darkening, by the application of stimulants and growth substances ; vernalization of the seedling by growing in boxes, applying short-day stimulation and planting out ; finally the treatment of seed by short-day stimulation of the parent generation and by stimulant substances. Up to the present only actual breeding has produced successful results. The following special technical measures have all been found to be unreliable and unsuitable for practical use :

1. Steeping the seed in water.
2. Steeping in stimulant solutions.
3. Vernalization (fourteen days in warmth and dark, germinated).
4. Growing in boxes, planting out.
5. Growing in boxes after stimulation, planting out.
6. Growing in boxes, short-day stimulation, planting out.

Simple methods of cultivation, together wth breeding work, afford the best means of overcoming the difficulty of growing an exotic crop plant : light soil, sowing in the last week of April, the abundant application of potassium and phosphoric acid fertilizers, acceleration of early development by loosening the soil.

It is possible to improve climatic conditions—apart from other methods—by intercropping.

In many places the growing of soybeans and maize in alternate 4 m. rows has been found successful. In young vineyards also the soybean has been found to grow very well between one and two-year-old vines ; it is very useful here at the same time as a valuable improver of the soil. Lowig (**7**) has grown the soybean successfully together with early potatoes ; between the 1 m. potato drills a soybean strip (two rows, 20 cm. apart) is sown after the potatoes have been earthed up (at the beginning of May) ; when the potatoes have been taken up a fodder soybean (green or ensilage soybean) is sown. The productivity of soybean and potatoes is—to say nothing of the not inconsiderable green weight of soybean obtained—considerably increased. For certain districts different kinds of intercropping employing the soybean will be

of importance. But for the large areas in soybean districts, however, only normal cultivation, simple, scientific and skilful, comes into consideration ; with the right choice of variety, good preparation of the soil, rational manuring, careful cultivation and harvesting, soybean grain growing must always be successful in a suitable region and a favourable situation.

## Harvesting, Utilization, Yield, Prospects

The soybean is grown as a grain crop ; the beans are intended for human consumption. Grain yield varies from 12 to 26 dz. per hectare, on an average a harvest of 16 dz. per hectare may be anticipated. To grow the soybean as a forage plant in Germany is non-admissible until more productive and rapidly growing varieties have been produced by breeding. Although Koenekamp's experiments (**5**) have shown that the soybean is superior to the sweet lupin in green weight and protein yield, the use of the soybean in Germany as a green fodder plant, for hay or ensilage, as is commonly practised in the United States of America, is for the present out of the question. Germany can grow as the main crop only very productive forage plants such as lucerne, sugar beet, maize, potatoes and some others ; the shortage of protein fodder must be rectified in the main through the improvement of grassland and by the growing of catch crops. Only if, in consequence of special circumstances, the maturing of a soybean crop is questionable, should the green weight be harvested and ensiled. It may be mentioned in passing that soybean straw and soybean chaff represent a good fodder.

While the soybeans which are imported (at the present time approximately 500,000 tons) are pulped and manufactured for oil, concentrated fodder and lecithin, it is intended to work the nutritive grains produced on German soil into flour. This valuable, fat-containing protein flour is used widely and for many purposes in household economy, in cooking on a large scale, in bakeries and in the food industry. Ziegelmayer (**17**) gives information on the various processes of soybean flour preparation. At a later date it will be possible to produce soybean oil and protein meal also from home-grown soybeans. Table 4 gives information on the composition of soybean flour with its full-value protein, and at the same time the chemical composition of soybean straw. Soybean straw furnishes good fodder for sheep, and when chopped for other animals also.

**Table 4. Chemical composition of full flour, extract meal and straw.**

| | Soybean flour per cent | Soybean meal per cent | Soybean straw Soybean chaff per cent |
|---|---|---|---|
| Protein .. .. .. | 40 | 52 | 5.6 |
| Fat .. .. .. | 20 | 1 | 2.4 |
| Carbohydrates .. .. | 24 | 30 | 41.2 |
| Ash .. .. .. | 5 | 6 | 7.3 |
| Crude fibre .. .. | 3 | 3 | 34.5 |
| Water .. .. .. | 8 | 8 | 9.0 |

Germany, like other nations lacking space, must attempt through the growing and consumption of soybeans and by other means to master its difficulties; the direct consumption of plant protein and plant fat must be increased as much as possible in order to avoid uneconomic and wasteful circumlocution through the stomach of the animal.

Since reference has been made to a limitation of meat consumption and a greater use of plant fat, it is not out of place to remember that meat for 75 per cent of the world's population is a more or less occasional component of the meal, and only for approximately 300 million people an important form of nutrition. Too great an emphasis on the expensive protein bearer "meat" must be rejected for economic and sanitary reasons. For the protein hunger of the present day the soybean is of extreme importance; in addition to a limited quantity of animal protein the body should receive an abundant supply of soybean protein, which can be used in the form of flour wherever meat, milk, eggs and fat are used. The soybean protein is a full-value, highly digestible, wholesome protein substitute with good keeping properties.

While a solution of the soybean problem, which certainly cannot be anticipated for at least ten years, may be able to eliminate for a long time all anxiety in Germany on the subject of protein and fat, even with a growing population, other solutions will probably be of use for exceptional times only, as human alimentation, like animal feeding, must always be based upon natural products. The production of fat and protein from inorganic substances—from coal and the air—is, however, very important for technical purposes. Yeast protein will play a part in the feeding of animals; fungus fat, however, will hardly be of importance for human alimentation.

In the United States of America, Henry Ford wishes to use soybeans for technical purposes, the oil for colours and lacquers, the protein for plastic substances and artificial resin; in Germany, with its limited space, home-grown soybeans can be used only for direct human alimentation. In America the growing of soybeans represents to a certain extent an insurance against unemployment and an opening up of new markets for surplus agricultural products; in this country, on the other hand, it is an economic measure for the cheap and wholesome alimentation of a densely populated land.

When properly grown the soybean contributes very greatly to the improvement and healthy condition of the soil; by reason of this physical, chemical and biological soil improvement it produces increased yield in every other crop plant. Through this general increase of yield it wins whole areas for itself, finally so many hectares that its production can reach a considerable height.

If the soybean area in Germany were doubled from year to year, in ten years the harvest from one million hectares would be available, so that—with an average yield of 16 dz. per hectare—50 grm. soybean flour per day per head would be available as supplementary alimentation. An ensuring and increasing of plant production, an ensuring and improvement of the people's alimentation are the results of successful soybean cultivation.

The soybean question in Germany is still in its infancy. Much has yet to be done by the breeder and by the agronomist, for resistance, reliability and productivity have yet to be improved, and cultural technique has to be simplified and improved with a view to ensuring good grain yield. In addition there is yet much educative work to be carried out in making the soybean grower an experienced cultivator and the user a willing consumer of the wholesome soybean flour. There are certainly many other important and urgent tasks to be carried out on behalf of a nation hampered by lack of space ; but the solution of the soybean problem may be of immeasurable value to the German people. The insurance of its food supply is the most important task by which Germany is confronted.

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# REVIEWS

## SPARTINA IN THE NETHERLANDS

THE economic possibilities of *Spartina Townsendii* have already been discussed in *Herbage Reviews*. 4. 151-3. 1936, when two papers by J. Bryce describing the utilization of the species in Europe and its attempted cultivation in certain set countries were reviewed. In the current year P. Jansen and J. G. Sloff (*Spartina* in Zeeland. *De Levende Natuur*. 1938. No. 12. 348-58) have reported on the distribution of *Spartina* in Zeeland. The maps accompanying the article are reproduced on p. 260. The following paragraphs are extracts from the paper by Jansen and Sloff.

In Vol. 29 of the same journal, Thijsse gave a short review of the history of this unusual grass, while in Vol. 39, Dr. Tuynman, in a description of the Sloe as a bird region, drew attention to the spreading of this grass. Since that time the literature on *Spartina* has increased enormously, and some of the questions raised by Thijsse may now be answered.

### ORIGIN OF SPARTINA TOWNSENDII

In the first place : what is *Spartina Townsendii* ? Is it a species which has been introduced from America, like *Spartina alterniflora* and *S. juncea*, or is it a hybrid ? A decision on this matter is closely related to the particular side of the Channel on which one happens to be. As early as 1908 the English, in accordance with the opinion of the agrostologist Stapf, believed that it must be a hybrid of *Spartina stricta* and *S. alterniflora*, which both grew in Southampton Water close by the locality where *Spartina Townsendii* was first observed and collected. In France the opinion was held that it constituted a good species which must have been introduced from elsewhere. Chevalier gave the following reasons for this theory :

1. On the French coast, where the plant had already been observed for twenty years, no *Spartina alterniflora* grew.
2. The pollen has always been present in abundance and is normally formed.
3. The seeds germinate well.
4. Vigorous reproduction is combined with constancy in all the organs.
5. For half a century not a single case of retrogression or segregation was perceptible.

According to French workers, *Spartina* is nothing other than a variety, with pubescent spikelets, of the American *Spartina glabra*, which grows in similar localities on the other side of the Atlantic.

In 1932 the late A. Saint-Yves, the French authority on grasses, published a Monographia Spartinarum and united therein all the European species of *Spartina*

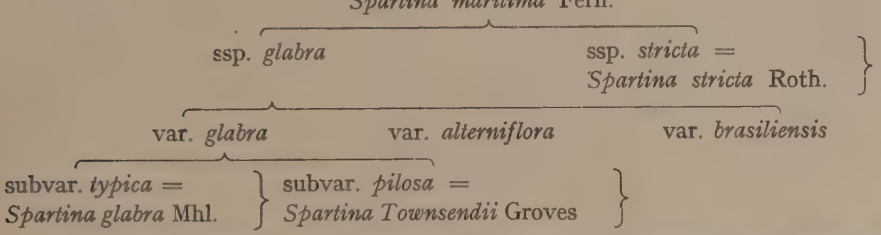
Spartina Townsendii in the Netherlands 1938

Spartina stricta in the Netherlands 1938

(with the exception of the south European *S. versicolor* Fabre, which he identified with the American *S. juncea*) under the name of *Spartina maritima* Fern. This large species he divided into two sub-species :

1. ssp. *stricta* (our *Spartina stricta* Roth.).
2. ssp. *glabra* (Muhl.) St.-Y.

This last is now divided into a number of varieties.




A cytological study of the problem was made by C. L. Huskins, who found that *S. stricta* has a somatic number of 56 chromosomes, *S. alterniflora* 70 chromosomes and *S. Townsendii* 126 chromosomes (*Herb. Abstr.* 1. 57. 1931).

A normal hybrid should have had (56 + 70) : 2 = 63 chromosomes. Hybrids of this nature exhibit the well-known phenomena of total to almost total sterility and segregation in any following generations. But Huskins assumes that *S. Townsendii* has arisen through hybridization and subsequent doubling of the chromosomes. This is also said to explain the fertility and great vigour of the plant. It is now only necessary for *Spartina stricta* and *S. alterniflora* to be artificially crossed in order to produce *S. Townsendii*. Considering the difference in time of flowering, however, this does not appear to be easy.

## Distribution in Zeeland

Whatever may be the taxonomic position of *S. Townsendii*, the authors state that on the Zeeland mud flats it gives the impression of being a good species. It is probably the large air spaces in the plant which permit it to root and grow in the soft mud, where lack of oxygen usually makes growth impossible for most other halophytes. When there is sufficient space the plant forms almost circular sods by the development of numerous lateral buds, thereby suppressing all other species including the natural border of *Spartina stricta*. In the Sloe and Braakman rivers, fields of *Spartina* can be seen as far as the eye can reach ; on account of the suspended matter collected they stand high above the original soil.

It still remains to be seen what will finally happen when the ground has become so high that it is submerged only at very high tides and when the *Spartina* has become so close that there is no room for another stem. It is not yet known whether it will thereby make life impossible for itself and whether its area will be invaded by other plants. The study of plant succession in this area promises to be very interesting so long as practical people do not intervene and enclose the raised land in polders. The grass is not of much economic value, being too short for thatch.

### Variability in the Species

As a result of a visit to the area the authors state, in contrast to earlier literature, that they were able to note great variability in the species. There were flowering plants from 0.2 to 1.5 m. high, with panicles of 2 to 20 ears, having a length of 6 to 20 cm.; the ears sessile or pedunculate, with a narrow or broad-winged rachis; spikelets 12 to 20 cm. in length, some very broad with much developed stigmas, others narrow but with stigmas scarcely emerging from the spikelets; the stamens, on the other hand, are very well developed. All these variations, however, are united by numerous intermediate forms, so that they seem of little systematic value. When the grass grows together with *Spartina stricta* one might expect to find forms which might be regarded as intermediate. The difference between the two species is not, however, very great: *Spartina stricta* is generally less tall and less robust, has fewer ears (two to five), narrower and darker leaves bent over at the tip, no ligule in the ordinary sense, but only a row of short hairs; towards the time of flowering the lowest sheaths readily permit the blades to fall (one of the best characters for identification); the spikelets are smaller and also somewhat shorter and more pubescent.

The authors then give a detailed description of the distribution of the species in the Netherlands, but this is of interest more particularly to those with a thorough knowledge of the locality. The maps reproduced on p. 260 will give an indication of the distribution of *Spartina stricta* and *S. Townsendii* in the Netherlands in 1938.

### Unusual Localities

Two remarkable localities from Zeeland, the lower area in the maps, may receive separate mention. First the Nieuw-Neuzen polder beyond Hoek-Terneuzen. There *Spartina* grows inside the dyke in a salt pasture trampled by cattle, together with *Puccinellia fasciculata*, identified in 1937 as extremely rare, and a large number of other grasses of salt grazings.

But by far the most interesting observation was that of the growth of *Spartina Townsendii* in sand and not in mud. In Vol. 31 of *De Levende Natuur* (August, 1926) the late Schipper described the vegetation of the flooded Sophia polder to the north-west of Wissekerke in North Beveland. The outermost edge of the ground, which is covered with tall plants, consists of sand brought down by the Roompot, which forms small dunes. There is *Triticum junceum* as a dune former, and also, according to Schipper, *Obione portulacoides*. And now *Spartina Townsendii* has also made its appearance. In addition to normally developed plants many stunted forms were noted. The stems, perpetually growing up through the dry sand, succeed in forming panicles, but the latter have not sufficient vitality to emerge entirely from the uppermost sheaths. The panicle branches are bent and the usually abnormally large spikelets lie close along the broad-winged rachis. The authors consider that this is the first time that *Spartina Townsendii* has been observed to act as a dune binder.

## HERBAGE PLANT IMPROVEMENT IN FINLAND

[Reviewer: R. O. Whyte]

The Plant Breeding Station, Tammisto, has celebrated its 25th anniversary by the production of a special issue of *Siemenjulkaisu*. This publication (Seed Report) usually appears at intervals of five years, but on this occasion only three years have elapsed since the previous issue.

The issue opens with an account by Dr. Otto Valle of the work of the Plant Breeding Station, Tammisto, during this period of 25 years. After an opening discussion of its origin and the development of its activities, Dr. Valle outlines the scope of the improvement work and the results obtained. When the Station was founded, the chief crops grown in Finland were old native varieties. Work has since


1. Central Agric. Exptl. Sta., Tikkurila.
2. Plant Breeding Sta., Tammisto, Malmi.
3. Pasture Exptl. Sta., Mouhijärvi.
4. Plant Breeding Div., Centr. Agric. Exptl. Sta., Jokioinen.
5. Horticultural Div, Centr. Agric. Exptl. Sta., Piikkiö.
6. Agric. Exptl. Sta., Kokemäki.
7. do. Pälkäne.
8. do. Antrea.
9. do. Mikkeli.
10. do. Maaninka.
11. do. Ylistaro.
12. do. Ruukki.
13. do. Rovaniemi.
14. do. for bog cultivation, Tohmajärvi.
15. do. for bog cultivation, Leteensuo.

**Agricultural Experimental Stations in Finland.**

been carried out, and is described, on winter rye, winter and spring wheat, oats, barley, peas (work on fodder peas discontinued in 1933), root-crops, potatoes, grasses and clovers. An article on the Plant Breeding Station, Tammisto, was published in *Herbage Reviews*, Vol. 1, No. 3.

Herbage improvement work has been carried out with all the more important species of grasses, including some introduced types. The following grasses have been placed on the market ; their chief quality as compared with foreign commercial varieties is their winterhardiness : meadow fescue (*Festuca pratensis*), cocksfoot (*Dactylis glomerata*), red fescue (*Festuca rubra*) and bluegrass (*Poa pratensis*).

The breeding of herbage grasses has been seriously retarded by the adoption of the Svalöf selfing procedure. Even the more distant inbreeding seems to have an adverse effect on the majority of pasture species. Good results are, however, now expected from the adoption of a new procedure with the most important of the Finnish hay grasses, *Phleum pratense*. In this procedure, inbreeding has been abandoned and attempts are being made, by means of crossings between individuals within the same strains or different strains, to evolve more valuable families than are represented by the original strains. The new breeding products are based on the best descendants of the crossings. Results indicate that in this way noteworthy results have been obtained in a short time.

In the early days of the Institute, much attention was devoted to indigenous red clovers (*Trifolium pratense*), but this work was frequently interrupted, partly due to the very unfavourable clover years which occurred in the 1920's. The first of Tammisto's early improvements to reach the market was Tammisto red clover (1937).

Improvement work on alsike (*Trifolium hybridum*) is proceeding to a lesser degree. Recently much work has been devoted to *Trifolium repens* and certain types which have been tested are being cultivated for seed ; true seed cultivation has, however, been almost impossible.

As the demand for pasture plants proper has proved to be far smaller than was expected, little attention has been devoted to these plants. Most work is now being carried out on the most important meadow plants, namely, *Phleum pratense* and *Trifolium pratensis*.

After this survey of the previous 25 years, Dr. Valle, who is most concerned with improvement of rye and herbage plants, deals more explicitly with the previous three years, that is, 1935-37. These three seasons were particularly favourable as regards plant growth. A detailed report is given of the damage to crops by insect pests and fungous diseases. Clover rot (*Sclerotinia trifoliorum*) frequently causes serious damage in the autumn at Tammisto ; during the period under review, however, the fungus appeared only in the year 1935 when the weather was rainy and humid. Damage was greatest in plots which had been severely affected in previous years. No damage was observed on land which had not carried clover for at least 10 years.

The report proceeds to deal with the improvement work on the crops mentioned above. It has already been noted that, as far as herbage plants are concerned, atten-

tion has been concentrated more particularly on clover and timothy, and that Tammisto red clover was placed on the market in 1937; this strain was derived from an old Tuulos (Central Finland) stock and has proved to be particularly persistent and rapid in forming aftermath. It was more resistant to clover rot than the other varieties tested. The most important step to be taken is to replace the commercial seed of the common red clover, the commercial value of which has been very valuable. A strain of white clover, from indigenous Finnish materials, has also been developed which is persistent and high in yield, but, owing to the difficulty connected with seed production of white clover, this strain has not yet been introduced on the market. Attempts are now being made to cultivate Tammisto white clover for seed, for example, in Hungary, Poland, Latvia and Denmark. As the seed production of red clover in Finland is more a provisional obtaining of seed than a true seed culture, a number of investigations have been made in an attempt to develop a seed culture technique for various kinds of clovers.

More attention has recently been paid to timothy than to any other hay grasses. No final results are yet available, for experiments have shown that even the comparatively distant inbreeding which has been used has had a weakening effect. Subsequent experiments to produce improved timothy by new methods are still in progress. Among other meadow grasses, it has been found that the strain E.F. 79 of *Lolium perenne* is exceptionally resistant at Tammisto. This Danish strain has been so successful that, in the spring of 1937, experiments were made for its cultivation in various parts of South Finland. It is possible that strains still more suitable for Finnish conditions may be developed from the same strain.

The next item in the Report is an account of the results obtained from comparative experiments with varieties at Tammisto in 1935-37. A considerable part of this section is devoted to grasses and clovers. Details are given of the strain tests on red clover, white clover and *Lolium perenne*, while those on alsike are discussed in a special section, reviewed below.

### Red Clover

The weather conditions at Tammisto were not favourable for tests on clover. In warm and humid autumns, clover rot proves very destructive, while great damage is also done by ice-burn, to which the clover varieties are very sensitive.

The fertilizers used for red clover are 300 kg. of Kotka phosphate, plus 150 kg. of 40 per cent potassium salt per hectare per annum. The plots also received an application of lime. Tammisto red clover was used as the control variety, with which the following strains were compared: commercial seed, the Finnish local strains Pinsiö, Ekerö, Parola and Tuulos, the Norwegian strains Molstad, Leinum and Toten and also a pair of strains bred at Tammisto from the Molstad strain. Two cuts were made during the summer and the test was continued even beyond the third winter, in spite of the thinness and weakness of the plots in the third year of the ley.

The Tammisto red clover gave 15 per cent more hay than the commercial strain, and a crop superior to the Finnish strains.

Certain other strains were tested in an experiment started in 1934 ; these included numerous foreign strains, namely, the best Danish strains, Øtofte early, middle late and late ; and the Estonian Jögeva and Putkaste. There were also a pair of local strains from Hollola and Helsinki respectively, as well as three lines of Tammisto red clover. The inclusion of the Danish Øtofte red clover was necessary, because in spite of its comparative southern origin it had been found that Danish Øtofte alsike was valuable at least in South Finland. Although this may be the case after a favourable winter the trials showed that the Øtofte red clovers are not so suitable in South Finland, nor are the Estonian red clovers comparable in cultivation value with the Finnish strains.

In another trial using Tammisto red clover as the control, three Øtofte strains and the South Swedish Harrie and Spannarp strains were compared, but they were all weaker than the Finnish strain and gave from 29 to 41 per cent lower hay yields. As the Harrie and Spannarp strains are the most esteemed of the South Swedish strains and as seed of the former, at least, had been imported into Finland, these results must be taken into consideration. After a poor seed year in Finland it may be necessary to import Swedish red clover, and it is pointed out that the importation should be made from Middle Sweden rather than from South Sweden. Local tests are in progress which will indicate the type of soil to which Tammisto red clover is best suited and how far to the north it can be cultivated.

### White Clover

This is the most important clover for Finnish pastures. The commercial seed comes from abroad, the best variety of foreign white clover being considered to be the Danish Morsø strain. The employment of white clover seed has been very rare in Finland owing to the fact that natural forms of this species spread rapidly in pastures and that the foreign strains are not sufficiently persistent for these conditions. Improvement work has been carried out at Tammisto for over 10 years and a number of strains are now ready. Unfortunately the seed production of white clover has proved so difficult that it has not yet been possible to produce enough Finnish seed for the market.

The strain tests with white clover were arranged in such a way that the legume was sown mixed with red fescue. Sown at the rate of 6 kg. white clover and 10 kg. of red fescue per hectare, fertilizer applications were made annually of 300 kg. Kotka phosphate, 150 kg. of 40 per cent potassium salt and 100 kg. of saltpetre per hectare. The harvest was obtained by mowing, which was carried out three times during the growing period if possible. The varieties compared were Morsø and Svea, a pair of indigenous strains, and the breeds of the Tammisto improvements. As the white clover was sown together with red fescue the harvest results did not give a clear picture of the cultivation values of the different strains. There are indications, however, that Tammisto II formed, with red fescue, the sward which was most free from weeds and richest in clover. No clover rot was observed on white clover in 1936, but in the spring of 1937 the Morsø and Svea strains were badly damaged.

The most resistant strains were the native varieties from Maaninga (9.5) and Helsinki (9.9), and also Tammisto II.

### Lolium perenne

Attention was first devoted to perennial ryegrass in the early 1920's, but at that time Svalöf Viktoria, which was considered to be the most persistent type, did not give good results. Thereafter little attention was paid to this species at Tammisto until it was found that the Danish E.F. 79 was a particularly persistent variety. As a result four strains of perennial ryegrass were compared in trials begun in 1935, namely, the Danish E.F. 79, Svalöf Viktoria, the Polish strain of K. Buszczynski of Warsaw, and the Scottish strain which the Valio Butter Export Company had imported into Finland with *Festuca pratensis* and *F. rubra*. The sowings were made in mixtures with white clover in the ratio of 25 kg. grass to 6 kg. white clover per ha.

In the spring of 1936 striking differences had been established between the wintering of these ryegrass varieties; Svalöf Viktoria was the worst and E.F. 79 the best, just as good as the Tammisto strain from *Festuca pratensis* and *F. rubra*. The Polish and Scottish strains were intermediate. The E.F. 79 strain gave in the first year at the third cut a more abundant crop than any other strain and than any other species. Compared with Svalöf Viktoria the hay crop was 25 per cent higher.

In the subsequent winter, 1936-37, various hay strains of *Lolium* perished almost completely. The E.F. 79 strain was also badly affected but was reasonably well preserved as compared with the others. *Festuca pratensis* and *F. rubra* were preserved under the same conditions without damage, so that not even E.F. 79 can compare with them for durability. It is probable that perennial ryegrass does not tolerate drought to the same degree as *Festuca pratensis* and *F. rubra*. When one considers the results from the first and second year meadows, E.F. 79 is certainly the best strain of perennial ryegrass, but it is clear that it is not so persistent as the native varieties of grass when the meadow grows old.

As, however, perennial ryegrass has many valuable qualities as a pasture plant and is a species which germinates and grows rapidly in the sowing year, it is essential that the practical possibilities of the species should be investigated in comprehensive tests. For this purpose it is recommended that pastures be sown with mixtures containing 3 to 5 kg. per hectare of the E.F. 79 strain. The employment of seed of this species was begun in Finland in the spring of 1937. Compared with the price of seed of other pasture grasses, perennial ryegrass is cheap, a fact which is calculated to facilitate its spread if the tests in the next few years are favourable.

### Alsike Clover

A considerable section of the Report is devoted to alsike clover (*Trifolium hybridum*) which is, after red clover, the most important legume species in Finnish meadows. It is certainly much less widely cultivated than red clover, but since 1918 quite considerable quantities of its seed have been imported from abroad, even up to 100,000 kg. per annum. As the Finnish production of alsike seed has been

small, most of the commercial seed has been imported from abroad, particularly from Sweden and Latvia; 80 per cent of the imported seed has come from the latter country.

As part of its work with herbage plants, the Tammisto Institute has carried out varietal tests with alsike since 1931, in order to determine the value of the seed available and whether it was more or less persistent than other strains. In all the tests Swedish red clover has been used as the control.

In the test started in 1931, five strains were included: Swedish, Latvian, the Danish Øtofte and the Finnish strains from Espoo and Piikiö. Great differences in the wintering of the various types were observed. The Latvian alsike was least persistent, having been seriously damaged by clover rot. The most persistent variety was the new Danish Øfofte improved variety. The good wintering of this Danish strain deserves special attention, as both the red and alsike clovers of Denmark have been regarded as wintering so badly that the importation of their seed from Denmark is forbidden. The Finnish strains were not any more persistent than the common Swedish commercial varieties.

In order to obtain evidence on the effect of time of cutting of the aftermath on the preservation of the alsike ley, the aftermath in all the test areas was not cut on September 1 of the 1932 trials, but was left uncut until the latter part of the autumn, namely, September 23, one plot being left uncut throughout the autumn as a control. Later cutting of the aftermath (September 23) had a more favourable effect on the preservation of the alsike than the earlier cut (September 1). The best preserved plots were those in which the aftermath had not been cut at all in the previous autumn. The harvest results in the spring of 1933 corresponded exactly to the wintering of the clovers.

The conclusion made at the end of the 1931 strain tests was that Øtofte alsike clover is a most important improved variety which deserves further attention.

In 1932, therefore, the same varieties were compared, with the addition of the Finnish Ilmajoki strain. Conditions in the following autumn were favourable to damage by clover rot and areas affected by this fungus were noted in the alsike plots, in spite of the fact that adjacent red clover plots of the same age were not at all affected. It was concluded by the end of the year that alsike is far more affected than red clover by wintering. The yield results were again the same, the largest crop being provided by the Øtofte strain. The Finnish and Swedish varieties were more or less equal.

This comparative variety trial was repeated in 1933 with the addition of three new types: the Swedish improved alsike Svea from Svalöf, the Estonian Vigala and the Finnish from Lavia. On this occasion clover rot did not appear in the autumn of 1933, and as a result the Latvian strain produced as good a yield as the Swedish. The Svalöf Svea improved strain was little superior to the ordinary Swedish commercial. Once again Øtofte maintained its superiority. Similar trials were carried out in 1934, 1935 and 1936, in which it was again noted that the Latvian varieties gave good yields when the clover rot was not serious and that the Øtofte variety is

highly resistant to clover rot. The two varieties which are regarded as most reliable for cultivation purposes are Danish Ötofte and the Finnish Lavia. It is possible that improved Finnish strains of Ötofte may be developed for Finnish use.

### Lathyrus pratensis and Vicia cracca

Early in the 20th century, tests of these species indicated that they were valuable herbage plants in long duration meadows where the herbage grows old and the clover diminishes and disappears. In spite of this early work and of more recent studies, no types of these plants have been used in meadow sowings, due partly to the expensive seed, and to the fact that practical experience did not confirm the early hopes. More recently, however, attention has again been paid to these types. Agron. B. Reims at Piikiö has cultivated these species extensively, produced seeds and spread their cultivation to different parts of Finland. Tests were begun in 1934, 1935 and 1936 at Tammisto and a report is now made of the results of the 1934 tests, of which three years' data are now available ; this particular test has been discontinued. It should be noted, however, that the results so far available of the 1935 and 1936 tests differ from those given below.

The tests were begun with " broadcast sowing" in early barley ; the plots were 10 sq. m. in size with 6 replicates. Scarified seed of the two species were used. The fertilizers were 300 kg. calcium phosphate + 150 kg. of 40 per cent potassium salt per annum. Two cuts were taken each summer, and botanical analyses made at the time of cutting, in order to discover the composition of the ley. The hay crop was measured in terms of dry matter, and in measuring the raw protein content, an attempt was made to obtain data regarding yield of protein. These comparative results were obtained from plots with the following mixtures (figs. in kg. per hectare).

| *Mixture* | |
|---|---|
| 1 | Timothy 20, red clover 10. |
| 2 | ,, ,, 5, *Vicia cracca* 5, *Lathyrus pratensis*, 5. |
| 3 | ,, ,, 5, *Vicia cracca* 10. |
| 4 | ,, ,, 5, *Lathyrus pratensis*, 10. |
| 5 | ,, *Vicia cracca* 5, *Lathyrus pratensis* 5. |

The results of this experiment show that both these species have a low cultivation value. Mixture No. 5 provided the lowest green crop, and the poorest raw protein content, in spite of the fact that the two species should have been able to develop well in the absence of the competition from red clover. In mixture 5 during the whole period, the average green crop of *Vicia cracca* was only 6.5 per cent and of *Lathyrus pratensis* only 8.8 per cent. In mixtures in which either or both of these species were combined with timothy and red clover, the percentage of these species in the crop was quite small. As the aftermath of these two species is also particularly bad, it does not appear that they deserve any special attention in meadow cultivation in Finland, at least under conditions in which red clover grows and persists well.

### Inoculation Tests at Tammisto

Inoculation tests in the field have been made at Tammisto on the following species :—*Trifolium pratense, Medicago sativa, Melilotus albus* and *Lupinus polyphyllus*. With *Trifolium pratense*, tests have been made, among other things, with

different strains of bacteria, but without any positive results. On the contrary, the influence of inoculation has been especially clear in all the other legume species investigated, owing to the fact that no bacteria for these species are present in Finnish soils.

### Improvement of Seed Production in Red and Alsike Clovers

Extensive studies have been made at Tammisto in 1933-37 concerning the seed production of red and alsike clover. The most important pollinating insects and insect pests of seeds have been studied separately. In the case of red clover, *Bombus distinquendus* and *B. lapidarius* have proved to be the most important pollinating insects. The significance of the honey-bee has been quite inconsiderable. On the other hand, with regard to the flowers of alsike clover, the honey-bee has been the most important, and only about 8 per cent of the whole number of pollinating insects have been humble bees.

Of insect pests of seeds the Apions (*Apion apricans* and *Apion flavipes*) are the most common. The use of Cryocid poison dust has given good results on seed swards.

The seed formation of alsike clover is greatly hampered by the tendency to germinate in the flower-head at the time of ripening of the seed. The more rainy the time of the harvest, the more seeds will be destroyed.

Considerable seed crops have been obtained at Tammisto, namely, as much as 600 kg. per ha. of red clover and 700 kg. per ha. of alsike clover. The object is further to ensure local seed production of these species.

### Seeds Mixtures for Temporary Clover-Timothy Leys

The object of the experiment has been to compare the following seeds mixtures (figs. in kg. per hectare).

| *Mixture* | | | | |
|---|---|---|---|---|
| 1. | red clover 20. | | | |
| 2. | ,, ,, | 15, | timothy | 15. |
| 3. | ,, ,, | 10, | ,, | 20. |
| 4. | ,, ,, | 5, | ,, | 25. |
| 5. | alsike | 15, | ,, | 15. |
| 6. | timothy | 30. | | |

The experiment has lasted 3 years and 2 cuts have been taken each summer. Whereas mixtures 1 to 4 have given almost equal hay crops, there have been very considerable differences between the yields of protein. Pure red clover (mixture 1) has given a protein yield about 20 per cent higher than mixture 4, in which the percentage of red clover has been smallest. Alsike clover has given much smaller yields than red clover. In spite of the abundant use of nitrogenous fertilizers, timothy has not been able to compete in the yields of hay and protein with those of red clover or red clover-timothy. As red clover, when sown alone, is not under all conditions sufficiently resistant, it is generally most profitable to prepare a sward from a seeds-mixture composed of 10 to 15 kg. per ha. red clover and 15 to 20 kg. per ha. timothy.

# RESEARCH AT A SOIL CONSERVATION EXPERIMENT STATION

In a publication entitled ' Soil Erosion Survey of Pennsylvania ' (Pennsylvania Agricultural Experiment Station, Bull. 354. 1938, pp. 23. Map) full details are given of the research programme of the Soil Conservation Experiment Station at State College, Pennsylvania. As this programme is more or less typical of the research in progress at a number of such stations in the eastern United States, it is reproduced here in full as an indication of the type of data which are being collected on arable land, orchards, pasture plots and forestry plots.

## Equipment

The research of the Soil Erosion Experiment Station is conducted on small plots, varying from one-fifth to one-seventh of an acre each. These plots are equipped with metal or earth side walls to prevent water from running on or off the plot. The bases of the plots are equipped with tanks or catch basins to receive the water and soil washed from the plots during a rain. On the smaller plots the entire run-off is collected and measured ; on the larger plots the run-off material is passed through divisors and only an aliquot portion of the run-off is retained for measurement and analysis. These divisors are metal boxes, in the front of which is a series of slots of equal size. A flume is attached to one of these slots and leads to a tank. In this way the run-off is split into a number of equal parts ; assuming that the divisor has nine slots, the portion of the run-off saved represents one-ninth of the total run-off.

Soil and water losses are measured after each rainfall which produces run-off. Measurements are made by volume and weight, the tanks being emptied by pumping and weights and measurement being made in calibrated steel drums. At the same time, samples are taken of the run-off material. The samples are weighed in the laboratory, evaporated to dryness, reweighed and the per cent of dry soil calculated. It is then possible to convert the actual run-off into pounds of soil and cubic feet of water lost per acre. The collecting and dividing equipment is provided with settling tanks to receive the heavier soil, baffle boards to control the flow of water into the divisors, and screens of various sizes to prevent trash from entering the divisors.

All plot work approximates field conditions as closely as possible. Wherever feasible, plots are worked with the customary field machinery. On the smaller plots, hand operations are carried out in such a manner to resemble field conditions.

## Control plots

The term " control plots " is applied to a series of plots each of which is small enough to permit all the run-off to be collected and measured. These plots are 6 ft. wide and vary in length from thirty-six feet to 145 feet. The different plots are separated by heavy sheet steel sunk in the soil to a depth of 15 inches. These plot dividers prevent water from running on or off the plots and then conduct the

run-off to the large tanks housed in a shed. The control plots are located on a slope averaging 13.42 per cent grade. A duplicate series of plots has been installed and soil sampling and yield determinations, but no run-off measures are made.

The factors which are studied in this series are the influence on soil erosion of different crops in the rotation, deep cultivation, length of slope, permanent pasture, fallowing, permanent alfalfa and desurfacing. The soil lost from the various plots is stored in bins so that, in addition to furnishing experimental data, the control plots give visual evidence of the effectiveness of different tillage and cropping practices in controlling erosion.

### Strip cropping

Strip cropping is an effective and practicable means of controlling soil erosion under certain conditions. The procedure is simple and interference with normal cropping practices is reduced to a minimum. The usual crop rotations can be carried out ; the only change is the rearrangement of large rectangular fields into a series of narrow fields running across the slope and following the contours. Tilled and non-tilled crops are alternated in such a way that the concentration of water on the tilled strips is reduced. The soil and water lost from these strips tend to be checked and held by the noncultivated strips.

Much more information is needed on the mechanics and the effects of strip cropping, such as the comparative effect of various rotations, width of strips, distribution of crops in adjacent strips, and comparison of strip cropping with ordinary field cropping on similar areas. Each of these factors will vary with soil type, degree of slope, length of rotation, character of precipitation and other conditions.

Eight strip-cropping plots have been established, each 21 feet wide and 300 feet long. The plots are separated by earth ridges 6 inches high and 8 inches wide. The use of earth dividers makes it possible to use ordinary field machinery in all tillage operations. The lower ends of the plots are provided with concrete troughs leading to collecting basins. Since these plots are quite large, aliquot divisors are used to obviate the necessity of measuring the entire run-off.

Three-year and four-year rotations under strip cropping are compared with the same rotation under the usual field cropping conditions.

### Tillage studies

Tillage practices, especially ploughing and cultivating, have a great influence on soil erosion. When land is ploughed in the autumn, run-off is accelerated if ploughing is done with the slope ; it is retarded if ploughing follows the contour. With spring ploughing these effects are not so marked. Cultivation is the most important factor during the growing season ; small channels produced by the cultivator shovels accelerate or retard erosion, depending on the direction of cultivation.

Little experimental data have been secured on run-off under various combinations of ploughing and cultivation. A series of tillage plots each 21 feet wide and 207 feet long has been established. The measuring equipment is like that described

under strip cropping. Corn is grown on these plots each year, since the crop is used only as a measure of the effectiveness of cultivation. Following are the plot treatments :

Plot 1.—Ploughed and cultivated with the slope.
Plot 2.—Ploughed with the slope, cultivated across the slope.
Plot 3.—Ploughed and cultivated across the slope.
Plot 4.—Ploughed across the slope, cultivated with the slope.
Plot 5.—Subsoiled across the slope in 1934. Ploughed and cultivated across the slope.
Plot 6.—Subsoiled with the slope in 1934. Ploughed and cultivated with the slope.

### Orchard cover crops

Since most Pennsylvania orchards are located on slopes in order to secure good air drainage, soil erosion has become an important factor, especially where cultivation has been practised. In 1935 the Soil Conservation Experiment Station installed a run-off plot in each of the several soil management treatments of a six-year-old apple orchard on the College farm. Each plot extends from one tree row to the next, and is 20 feet wide and 218 feet long. The slope averages 5.13 per cent. All cultural operations are performed with the usual field machinery.

The following soil management treatments are under investigation :

Plot 1.—Annual cultivation with two cover crops. A seedbed is prepared twice each year. A mixture of millet and buckwheat is seeded in the spring, and rye or wheat in the autumn.
Plot 2.—Annual cultivation with one cover crop. A mixture of clovers is seeded each spring.
Plot 3.—Permanent bluegrass sod mowed several times each year and cultivated in the spring to check sod growth.
Plot 4.—Permanent alfalfa mowed several times during the year and cultivated in the spring to check the growth of bluegrass.
Plot 5.—Duplicate of Plot 2, except that nitrogen fertilizer is added.
Plot 6.—Duplicate of Plot 1, except that nitrogen fertilizer is added.

### Pasture plots

In all sections of the country permanent pastures and grasslands play an important part in soil conservation. The most effective combinations of species depend on the climate, slope, soil type, pasturing conditions and other factors. It is desirable that information be available on the relative value of different species in controlling erosion, ease of establishment on slopes, survival and reasons for difference in value for erosion control.

A series of pasture plots has been established on the College farm on a slope averaging 21.15 per cent. The plots are 10 feet wide and 145 feet long, and separated by corrugated sheet-iron strips sunk in the soil to a depth of 13 inches. The catch basins and measuring equipment are similar to those previously described. When a permanent grass cover has been established the plots will be pastured or yields will be obtained by mowing them at intervals during the growing season. Records are made of survival, persistence, rate of establishment and other factors.

The following plots have been established:

Plot 1.—Original sod treatment. Potash and phosphate added.
Plot 2.—Original sod. No treatment.
Plot 3.—Original sod. Phosphate added.
Plot 4.—Kentucky bluegrass (*Poa pratensis*) and domestic ryegrass (*Lolium perenne*).
Plot 5.—Pasture mixture (Kentucky bluegrass, redtop, timothy, white, red and alsike clover).
Plot 6.—Smooth bromegrass.
Plot 7.—Kentucky bluegrass and Ladino clover.
Plot 8.—Kentucky bluegrass and wild white clover.
Plot 9.—Kentucky bluegrass and orchard grass.
Plot 10.—Fallow. No treatment.
Plot 11.—Kentucky bluegrass and meadow fescue.
Plot 12.—Kentucky bluegrass and redtop.
Plot 13.—Kentucky bluegrass and timothy.
Plot 14.—Kentucky bluegrass and white Dutch clover.
Plot 15.—Kentucky bluegrass.

### Forestry plots

Many soils and slopes are unsuitable for cropping or for pasture purposes and can more profitably be used for forest plantings. Some of the questions to be answered are:

(1) To what extent do the different species of forest trees prevent soil erosion ?
(2) To what extent is stand density a factor in soil erosion ?
(3) What trees and types and what conditions produce a forest floor that is most resistant to erosion ?
(4) Is coniferous forest litter more effective for soil conservation than hardwood litter ?
(5) To what extent do forest fires influence soil erosion ?
(6) How effective are tree roots in preventing or checking erosion ?

Field studies were made in 1934 under natural forest conditions to determine the causes of soil erosion and the factors contributing to the prevention of soil wastage. Investigations are under way on the relative effectiveness of different types of forest litter, using an artificial rainfall apparatus, by means of which precipitation can be controlled and the percolate as well as the run-off can be measured. Several plots of young forest trees, similar to the pasture plots, were established in 1935. Measuring equipment will be installed on these plots.

## PASTURE IMPROVEMENT IN EASTERN CANADA

[Reviewer: R. O. WHYTE]

THE importance of pasture in Eastern Canada, both with respect to the extent of the area it occupies and its economic value, has been greatly under-estimated. It is probably the most neglected crop grown on the farm and too often it consists of the roughest and most unproductive weed and brush infested areas. Moreover, pasture fertilization has seldom been considered and little or no attention has been paid to grazing management. In recent years a greater realization of the economic possibilities of pasture lands has developed, and the pasture problem is at last receiving the attention it rightly deserves, by both the farmer and the investigator. Increased effort is now being made through the co-operation of experimental stations, agricultural institutions and fertilizer firms, to improve the pasture situation in Eastern Canada.

An account of the pasture improvement investigations being conducted by the Dominion Experimental Farms has been published by the Committee in charge of Pasture Investigations, Central Experimental Farm, Ottawa, with the co-operation of the Pasture Committee of the Ontario Agricultural College, Guelph, Ontario (Canada, Department of Agriculture, Publ. 602. Fmrs' Bull. 51. Pasture Improvement in Eastern Canada. Ottawa, 1938. pp. 70).

Table 1, quoted from Publication 602, shows the total area of occupied agricultural land in Canada and the total acreage of grain, hay and pasture lands.

**Table 1.—Acreage of pasture compared with hay and grain in Canada.**

| Province | Total agricultural land | Grain | Hay | Pasture | | |
|---|---|---|---|---|---|---|
| | | | | Improved | Natural | Total |
| | Acres | Acres | Acres | Acres | Acres | Acres |
| Prince Edward Island | 1,191,202 | 196,640 | 235,022 | 242,195 | 35,264 | 277,459 |
| Nova Scotia | 4,302,031 | 105,089 | 420,816 | 168,303 | 744,971 | 913,274 |
| New Brunswick | 4,151,596 | 281,988 | 593,247 | 292,687 | 238,855 | 531,542 |
| Quebec | 17,304,164 | 2,034,880 | 3,764,957 | 2,600,757 | 1,430,974 | 4,031,731 |
| Ontario | 22,840,898 | 4,968,977 | 3,710,747 | 2,943,567 | 3,460,398 | 6,403,965 |
| Total Eastern Canada | 49,789,891 | 7,586,574 | 8,724,789 | 6,247,509 | 5,910,462 | 12,157,971 |
| Manitoba | 15,131,685 | 5,432,820 | 295,642 | 411,924 | 3,601,644 | 4,013,568 |
| Saskatchewan | 55,673,460 | 21,752,661 | 173,488 | 712,371 | 15,755,179 | 16,467,550 |
| Alberta | 38,977,457 | 11,321,676 | 296,993 | 524,586 | 15,960,335 | 16,484,921 |
| British Columbia | 3,541,541 | 172,034 | 192,714 | 115,326 | 1,347,377 | 1,462,703 |
| Total in Canada | 163,114,034 | 46,265,765 | 9,683,626 | 8,011,716 | 42,574,997 | 50,586,713 |

### COST OF PRODUCTION

It is now possible to make a comparison of the cost of producing pastures as compared with other field crops, as a result of the introduction of a suitable method of determining the productive capacities of pastures. Table 2 (4 in text) shows the

cost of producing pastures as compared with six commonly grown farm crops at the Central Experimental Farm, Ottawa, based on the average yields from 1932-1935.

**Table 2.—Yield and cost of producing crops—1932-35. Ottawa.**

| Crop | Yield per acre | | | Analysis (per cent) | | | Cost per acre | Cost per ton | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Moisture Free Basis | | | | |
| | Field cured | Dry matter | Total digestible nutrients | Dry matter | Digestible protein | Total digestible nutrients | | Dry matter | Total digestible nutrients |
| Bluegrass pasture (fert.) | tons or bu. 6.10 | tons 1.67 | tons 1.20 | 28.7 | 15.3 | 71.7 | $ cts. 9 56 | $ cts. 5 72 | $ cts. 7 97 |
| Alfalfa hay | 3.92 | 3.09 | 1.72 | 78.8 | 11.7 | 55.6 | 19 34 | 6 26 | 11 24 |
| Clover hay | 3.06 | 2.42 | 1.42 | 79.1 | 7.9 | 58.8 | 20 16 | 8 33 | 14 20 |
| Timothy hay | 2.90 | 2.21 | 1.17 | 76.3 | 3.3 | 52.9 | 15 93 | 7 21 | 13 61 |
| Corn silage | 18.37 | 3.87 | 2.56 | 21.07 | 4.6 | 66.1 | 44 34 | 11 46 | 17 32 |
| Mangels | 24.00 | 2.26 | 1.75 | 9.4 | 10.6 | 77.6 | 50 78 | 22 47 | 29 02 |
| Barley (grain) | 45.2 | 0.98 | 0.85 | 90.4 | 9.3 | 87.0 | 21 93 | 22 38 | 25 80 |
| Oats (grain) | 61.5 | 0.95 | 0.75 | 91.5 | 9.4 | 78.5 | 21 09 | 22 20 | 28 12 |

## Pasture Types and Botanical Survey

Under the heading of types of pasture are included (a) permanent pastures, which may or may not have been broken up and reseeded; (b) pastures included in a crop rotation; and (c) annual or supplementary pastures which may be used to provide feed when the permanent or rotation pastures have been injured by drought or winter killing. Details are given regarding climatic, plant and soil variations which occur in Eastern Canada. Inventories of plant species have been obtained by means of botanical surveys conducted on experimental farms. The results of these surveys also provide a means of recording the effects of cultural, fertility and management experiments on the pasture flora; a knowledge of the indigenous species is also of value in making decisions regarding the introduction of new or improved species. The following are some of the lessons learnt from the botanical survey.

1. In practically all stands of vegetation some improvement can be effected by fertilizing, liming or manuring, and in certain cases the response has been rapid and well marked.
2. Grasses respond to complete fertilizers to a greater degree than do legumes and most weeds.
3. Legumes are less dependent on nitrogen than are grasses and may be suppressed by the application of nitrogenous fertilizers.
4. Couch grass responds strongly to fertilizers, and especially to nitrogen. It is also stimulated rather than suppressed by the tillage operations involved in reseeding pastures.
5. Rotational grazing is little, if at all, different from continuous grazing in its effects upon the vegetation. The tramping of stock or the absence of it, however, makes a great difference. The use of the mowing machine to keep the grass short and promote fresh leafy growth favours some species more than others, and especially encourages the rapid development of white clover.
6. White clover with proper fertilization and grazing management can increase very rapidly. It may vary very considerably from year to year with changes in weather conditions.
7. Ox-eye daisy and orange hawkweed are examples of weeds which diminish under fertilization.

## Pasture Improvement Investigations

Pasture improvement investigations are being conducted at the Central Experimental Farm, Ottawa, and at the following points in Eastern Canada: Lennoxville, Ste. Anne de la Pocatière, Cap Rouge and nineteen Illustration Stations in Quebec; Fredericton and eight Illustration Stations in New Brunswick; Kentville, Nappan and eleven Illustration Stations in Nova Scotia; Charlottetown and seven Illustration Stations in Prince Edward Island; and at the Harrow and Kapuskasing stations in Ontario.

## Obtaining and Recording Pasture Production

Specially equipped lawn mowers or tractor plot mowers have been developed for obtaining grass yields from small cage-protected areas in grazed fields. These cages are located in sufficient numbers to obtain representative yields from each area. These protected areas are clipped and the cages moved to new locations at intervals as required. In this way clippings are made on areas which have previously been grazed and thus simulate pasture conditions, while provision is made for a randomized sampling of the vegetation. The weights of grass are recorded for each clipping and samples are taken for chemical analyses. The total weight of grass recorded represents one means of measuring the productivity of the pasture for the season.

Methods of determining the results of experiments have also been adopted so that the animal carrying capacities of the pasture and gains in body weight or milk of grazing animals may be compared on a uniform basis.

## Calculating Animal Unit Carrying Capacity

*Total Digestible Nutrients.*—The carrying capacities of pastures are calculated from the total digestible nutrients produced by the pastures. These in turn are determined on the basis of the total digestible nutrients required for the body maintenance of a given animal and those required for production, be it milk or gain in live weight. If no supplementary feeds are fed, the total digestible nutrients will be those which the animal has secured from grazing. If supplementary feeds are fed, the total digestible nutrients from the feeds are subtracted from the gross total digestible nutrients and the difference is that which has been furnished by the pasture.

*Animal Unit.*—The conversion of the total digestible nutrients furnished by the pasture into "carrying capacity" necessitates the use of a convenient unit. In practice, it is customary to designate a mature milking cow as one head. A 1,000 pound milk cow producing 25 pounds of four per cent milk daily is therefore selected as one unit. Such a cow requires daily, for maintenance and production, 16 pounds of total digestible nutrients. This amount is, therefore, considered equivalent to a carrying capacity of one "Animal Unit," and it remains the same irrespective of the class of livestock used. The method of calculation is to divide the total digestible nutrients per acre by the number of grazing days multiplied by 16. This converts the result to a standard unit called the "Animal Unit Carrying Capacity per Acre."

Since the length of the pasture season varies considerably the results are made comparable by adjusting them to a standard grazing season of 150 days, which is the average length of the pasture season in Eastern Canada.

In order to apply this system, it is necessary to determine the digestible nutrient requirements of the various classes of stock, whether it be dairy cattle, beef cattle or sheep. Allowance must also be made for animals in gestation or nursing their young. Once the requirements are determined and the calculations made, it is possible to compare the carrying capacities of different pastures on a standard basis, even although various classes of animals have been used.

*Standard Animal Equivalent.*—Although this method is necessary to compare properly the productivity of different pastures when different kinds of stock are being used, it is sometimes desirable for practical purposes to express these units in terms of a " standard animal " of the class or species desired. In the selection of a " standard animal" one cow weighing 1,000 pounds and giving 25 pounds of four per cent milk daily is taken as a standard milch cow, one heifer averaging 600 pounds in weight for the season and gaining 1.2 pounds a day, as a standard heifer ; one steer averaging 700 pounds in weight during the season and gaining 1.67 pounds a day, as a standard steer ; and one 130-pound nursing ewe with her lamb averaging 50 pounds for the season and gaining 0.4 pounds daily, as a standard sheep.

The daily nutrient requirements of these animals are then calculated and, by taking 16 pounds of total digestible nutrients as a unit, it is possible to express the digestible nutrient requirements of each animal as a fraction of this unit, thus :

1.0 animal unit—1 cow weighing 1,000 pounds and giving 25 pounds of four per cent milk per day.
0.5 animal unit—1 dairy heifer averaging 600 pounds and gaining 1.2 pounds daily.
0.6 animal unit—1 steer averaging 700 pounds and gaining 1.67 pounds daily.
0.2 animal unit—1 nursing ewe averaging 130 pounds with her lamb averaging 50 pounds and gaining 0.4 pounds a day.

## Fertility Experiments on Pastures

Experiments in pasture improvement by the Dominion Experimental Farms first took the form of preliminary fertilizer trials. Since that time the investigational work in this field has rapidly increased at the Central Experimental Farm, Ottawa, and at a number of Dominion Experimental Stations in Eastern Canada. The experiments now in progress include investigations with regard to the economical use of manure and commercial fertilizers, fertilizer formulae, rates and dates of application, and other points connected with pasture fertility.

The following is a list of aspects being studied, each of which receives detailed consideration in publication 602 :—

Fertilizer versus no fertilizer on Dominion Experimental Farms.
Results of fertilizer tests on Illustration Stations in Eastern Canada.
Rates of applying commercial fertilizer for pasture.
Rates of applying nitrogenous fertilizers.
Rates of applying nitrate of soda at Fredericton, N.B.

Commercial fertilizer formulae experiments.
On plots cut for hay.
On grazed field.
Date of applying commercial fertilizer for pasture.
Summer applications of nitrogen.
Frequency of applying mineral fertilizers.
Sources of commercial fertilizer elements.
Nitrogen.
Sources of phosphoric acid.
The use of lime on pastures.

## Management of Permanent Pastures

The problems being investigated at Ottawa and on several other experiment stations are as follows :—

Rotational versus continuous grazing.
Light versus heavy grazing.
Height of clipping experiments.
Frequency of clipping experiments.
Renovating rough pastures.
Pasture in a crop rotation.
Pasture species and seed mixtures.

Consideration is then given to the adaptability of the various grass and legume species under Eastern Canadian conditions; the grasses include *Phleum pratense*, *Poa pratensis*, *P. compressa*, *Agrostis* spp., *Festuca rubra*, *F. pratensis*, *Lolium perenne*, *L. multiflorum*, *Dactylis glomerata*, *Arrhenatherum elatius*, *Bromus* spp., crested wheatgrass and slender wheatgrass (*Agropyron* spp.), and *Phalaris arundinacea*. Among the legumes are red clover, alsike, alfalfa, white clover and Ladino clover.

Some tentative conclusions may be made from the experiments in progress to determine the place and value of wild white clover in Eastern Canada :—

1. Wild white clover in Eastern Canada is of most value in association with the native grasses on non-arable land.

2. Wherever wild white clover thrives naturally in permanent pastures it is likely to be the most important factor in their improvement.

3. An ample supply of phosphates in the soil and close grazing are essential requirements for the best development of wild white clover. It is fairly tolerant of soil acidity, but sometimes responds to treatment with lime.

4. The use of wild white clover in seeded pastures that are intended to provide one or two crops of hay is not likely to be profitable because the clover is easily eliminated by shading. If the crop is to be utilized for pasture only, and the soil and climatic conditions are favourable for its growth, wild white clover can be a valuable component of permanent mixtures. The shading effect of other grasses and legumes will be prevented if the herbage is adequately grazed.

5. Experiments at Ottawa have shown that wild white clover in association with different grasses and grass mixtures more than doubled the yields of pasture herbage and produced about five times as much protein per acre as compared with the same grasses and grass mixtures without the clover.

Among other problems being studied is a comparison of different types of pasture mixtures with varying frequencies of cutting. Table 3 shows the yields of dry matter in pounds per acre of different mixtures cut five and nine times per season respectively.

**Table 3.—Yields of dry matter in pounds per acre of different mixtures.**

| Mixtures | 1934 | 1935 | 1936 | Average |
|---|---|---|---|---|
| | Cut five times per season | | | |
| 1. Timothy, red clover and alsike | 4,777 | 3,181 | 3,769 | 3,909 |
| 2. Same as No. 1 plus bottom grasses* | 5,243 | 3,463 | 3,521 | 4,076 |
| 3. Same as No. 2 plus alfalfa | 6,586 | 4,761 | 5,778 | 5,708 |
| 4. Timothy, Kentucky blue and wild white clover | 3,603 | 3,332 | 1,451 | 2,795 |
| | Cut nine times per season | | | |
| 1. Timothy, red clover and alsike | 4,440 | 2,609 | 2,654 | 3,234 |
| 2. Same as No. 1 plus bottom grasses* | 4,669 | 3,458 | 2,253 | 3,464 |
| 3. Same as No. 2 plus alfalfa | 5,746 | 2,781 | 3,042 | 3,856 |
| 4. Timothy, Kentucky blue and wild white clover | 3,759 | 3,362 | 1,622 | 2,914 |

*Kentucky blue grass (*Poa pratensis*), red top (*Agrostis* sp.), and white Dutch clover (*Trifolium repens*).

Of about forty different crops and combinations of crops which have been compared during the last four years both by clipping the herbage in test plots and by grazing with dairy cows under field conditions, oats and Sudan grass were found to be the best crops for supplementary pasture.

Tabulated information is given regarding the chemical composition of pasture plant species, depending upon variety of herbage, stage of maturity, fertilization and climatic conditions. Details are also given regarding the protein, mineral and vitamin content of the various pastures and their palatability.

The Bulletin concludes with recommendations (not hard and fast rules) for pasture management and improvement.

## ECOLOGICAL SURVEY OF THE MOUNTAIN AREA OF BASUTOLAND

[Reviewer: R. O. Whyte]

The mountain area of Basutoland is a high, massive mountain block of very rugged topography comprising about three-quarters of the territory. Only fifty years ago this area was the home of herds of eland, which were hunted by Bushmen with their poisoned arrows and later by Basuto on their fast ponies. The eland have now disappeared and numerous native villages are to be seen with their cultivated lands

around them in most of the valleys, while the steep mountain slopes are grazed by many sheep, goats, cattle and horses. This settlement of the area, which is also an important watershed, has been accompanied by serious changes, particularly in the vegetation. In his report on " The financial and economic position of Basutoland" Sir Alan Pim recommended that an ecological survey should first be made as an initial step to the necessary programme of reclamation and conservation. It was recommended, and later agreed, that a grant should be made to cover the cost of the survey and the related experiment programme over a period of five years. Work was started on October 1, 1936, and the publication now under review represents the report of R. R. Staples and W. K. Hudson on their ecological survey. (An ecological survey of the mountain area of Basutoland. London. 1938. 33 × 21. pp. 68. pls. maps).


The survey party consisted of R. R. Staples, ecologist loaned from the Tanganyika Government Service; assisted by F. A. Venter, a Government geologist from the Union of South Africa, for the first month, and W. K. Hudson, of the Basutoland Public Works Department, as surveyor for the whole period of the survey. The whole organization of the survey party and its attached native staff and guides was carried out by the Agricultural Officer, L. F. Wacher, whose knowledge of the mountains was of great value to the party.

The introductory sections describe the geology, topography, climate and rainfall, and soils of the mountain area. Judged by South African standards, the soils, due to the favourable composition of the parent rock, seem to be of unusual fertility, as may be seen from the soil analyses. This is reflected also by the conditions which stock maintain and the excellent crops of wheat and peas where adequate cultivation has been given. In pedological language, the dominant feature of these soils is that they exhibit a greater or lesser degree of podsolization, that is, they are highly leached soils formed under grassland and contain an accumulation of dark-coloured, acid humus in the surface layer. Beneath the darker top-soil is a lighter-coloured horizon of coarser texture varying greatly in its thickness. Beneath this again is decomposing rubble of the basalt rock.

The vegetation map attached to the report as Annexure C represents an attempt to classify the vegetation into three main pasture types as a basis for the development of a grazing policy. A special section of the report is devoted to a description of the two grassland types, as they constitute the natural vegetation of the mountain area developed under the influence of periodic firing. The evidence of many of the older inhabitants confirms this assumption. The third type (scrub) has developed as a result of overgrazing over quite a short period of years and is described in the section dealing with the deterioration which has taken place in the pastures.

It soon became apparent that the variations in the botanical composition, apart from those caused by overgrazing, which do exist in the mountain pastures, were primarily due to climatic changes owing to the great range in altitude and differences in aspect. The larger dolerite dike areas, where the dike rock has weathered more quickly or more slowly than the adjacent basalt rock, were observed to affect, but usually only slightly, the botanical composition of the pasture sward, and the change from basalt to sandstone soils has frequently an even more marked effect on the prevalence of certain associated species or the percentage frequency of the dominants, but even here not sufficiently to produce a change from one type to another.

The two main pasture types are :

**1. Seboku grassland.**

*Seboku* is the general Sesuto term for the grass *Themeda triandra*, also known in South Africa as "redgrass", "rooigras", or "rooigrass" and sometimes as "sweet grass" or "sweet veld."

**2. Letsiri grassland.**

*Letsiri* is the Sesuto term usually applied to the grass *Festuca rubra* or *Festuca caprina*—which are not distinguished by the Native herdboys or stock-owners—but is also used for several species with similar leaf growth, for example, *Koeleria cristata* or *Danthonia disticha*. In this type the fescues are the normal dominants on the best soils, usually at the lower altitudes, and the Danthonia on the poorer soils at the higher altitudes, but in both cases the Native description will be "*letsiri* veld."

The third type given on the vegetation map and developed through overgrazing is :

### 3. Sehalahala scrub.

*Sehalahala* is the Sesuto term for "small bush." By far the most important species in the extensive scrub areas is *Chrysocoma tenuifolia*, which in the north is generally called "*sehalahala*," but in the Qacha's Nek district and central Basutoland is termed "*sikikitlela*," and in the Quthing district "*mamatasi*," or "*torina*"; elsewhere in South Africa as "bitter Karroo bush" or "bitter bossie." As the type sometimes is an admixture of bush species the term "*sehalahala*" is used in preference.

The areas occupied by this low-growing scrub vegetation were at one time either *seboku* grassland (at the lower elevations) or *letsiri* grassland (at the higher elevations) and more usually still support a fair proportion of these grasses.

Following a detailed description of the characteristics of *Seboku* and *Letsiri* grassland, the next main section deals with the utilization of the mountain area under the headings of (1) History, (2) Agriculture, (3) Pastoral industry, (4) Carrying capacity of the mountain pastures, and (5) Economic value of the mountain area.

An account is then given of the changes which have taken place with use. On the subject of deterioration of pastures consideration is given to the encroachment of *Sehalahala* scrub, the increase of ragwort (*Senecio retrorsus*), the replacement of *seboku* at lower altitudes by less desirable species, and denudation. A rough estimate is that about 2,750,000 acres have been badly affected and a conservative estimate is then made that the carrying capacity of the area as a whole has been reduced by 25 per cent.

The decrease in the carrying capacity through the encouragement of useless or poor fodder species, although a serious loss in itself, is not so important a matter as the destruction of the plant cover with the consequent loss of soil through accelerated erosion. The prevention and control of this are considered to be the most important and pressing of the problems requiring immediate attention.

The mountain area of Basutoland forms the heart of the most important watershed in South Africa and provides 32.8 per cent of the usable run-off from the whole of the Union and Basutoland. Considering the comparatively low rainfall, the number and strength of the streams from the well-grassed areas give ample testimony to the effectiveness of the unimpaired grass cover as an absorbing agency. The direct run-off under such conditions appears to be low, but the shallow depth of the soil results in saturation and a rapid increase in spring-flow. Afforestation, if possible and if protected from grazing, would probably improve the watershed conditions at the higher elevations where the temperatures are low enough to prevent excessive transpiration. The majority of the mountain streams arise in the high-lying *Festuca-Danthonia* grassland which appears to be relatively unimpaired as regards its watershed qualities. Streams from this area are comparatively clear after each storm as compared with the mud torrents originating from areas covered by *sehalahala* scrub or the overgrazed *seboku* pastures. In this connexion the question of water supplies for irrigation, stock-drinking and domestic purposes is important.

## Recommendations

The following recommendations are submitted by Staples and Hudson as being necessary for the protection of the mountain area. These have been abridged for the purpose of this review.

### A. Pastoral.

(1) Introduction of grazing systems.

Cattle post areas. (i) Where the *sehalahala* bush has encroached, those slopes which have bush (that is, roughly, northern, north-eastern and north-western slopes) should be reserved for winter grazing.

(ii) Where the bush has not as yet encroached, it will be more convenient to reserve the northern and eastern slopes for winter use. In this system, therefore, the grazing from the beginning of November to the end of April will be confined chiefly to the *letsiri* pastures on the southern slopes.

Village areas. All village pasture lands (excluding thatching grass reserves), including those of the lowlands, should be divided into three approximately equal parts, with a system of landmarks and beacons, and each part reserved in rotation for winter grazing, from the beginning of November until the end of the following May.

These two systems of grazing would be *merely a development of the age-old Basuto custom of maboella or "spare-veld."* The low standard of the herd-boys in charge of the stock at the cattle posts may be the greatest obstacle in enforcing the system of grazing in the high mountain country, as it will entail much closer herding of stock, particularly cattle and horses, than is done at present. However, the chiefs with whom the matter was discussed thought that the enforcement of both systems would be practicable, providing they had the backing of the Paramount Chief.

In certain areas difficulty may also be experienced in obtaining the right proportion of the various slopes or pasture type, but this will be exceptional. It may entail the use of two cattle posts, one for the summer, and one for the winter, which would be no great hardship, considering the temporary nature and crudeness of the huts and kraals in general use.

It will, however, be essential to have the necessary tribal legislation passed and the whole-hearted support of the Paramount Chief as well as European supervision to see that the grazing rules are enforced. The duties would naturally be a part of the work of the Sheep Inspectors.

It is felt that, if this is obtained, the possibility of carrying out these grazing schemes without the use of fencing is more possible in Basutoland than in most Native areas, owing to the strong tribal system and the obedience which the chiefs command. Some difficulty is anticipated with the marginal areas between the cattle post country and the village areas of the mountains, and for this reason the following recommendation is made :

(2) A trial fencing off of the purely grazing country.

A rough estimate of the amount of fencing which would be needed to fence off the whole of the cattle post areas is 1,500 miles and the cost £75,000. Before recommending an expenditure of this magnitude, the grazing systems should be given a fair trial. Meanwhile, we recommend the fencing off of a suitable experimental area at a maximum cost of £1,000. Apart from the advantage which such a fence would be in the carrying out of the two grazing systems advocated, it could also serve a valuable need in controlling the extension of cultivation to altitudes unsuitable for the economic production of crops. Later, if found necessary, it would not take so very much cross-fencing to divide the purely pastoral country into paddocks in order to control the grazing more closely.

(3) Prevention of stock theft.

(4) Limitation of the number of stock in accordance with the carrying capacity of the pastures.

This recommendation is felt to be the one of primary importance if the mountain pastures of Basutoland are to be preserved for the future benefit of the Basuto nation.

Large areas are to-day understocked as the result of the enormous reduction in numbers, and with better distribution of the stock no part of the country would be overstocked at present. But it will probably be only a matter of a few years before wholesale overstocking will become general again, and in the mountain area with unlimited numbers it is doubtful whether any system of grazing will prevent serious damage to the pasture and to the watershed.

With the reduced numbers of stock it seems a particularly opportune moment to introduce the principle of *limiting the number of stock in each dipping-tank area in accordance with its carrying-capacity*, as with the ready movement of stock it would not at present entail any forced sales. The permanent solution of this difficult problem is, however, a matter for the Administration of the country, to whom it can safely be left.

(5) The institution of stock markets.

Such markets appear necessary to satisfy the requirements of the internal traffic in stock as well as the extensive export trade in oxen and to a less extent horses. The recommendation, however, is made chiefly because properly organized markets in native areas (Zululand, Tanganyika) have been found to encourage the sale of stock, which will tend to relieve the congested areas, although it is thought only temporarily.

(6) The introduction of a stock tax or grazing fee.

Apart from the limiting of stock in accordance with the carrying capacity of the pastures, it is thought that no other measure would have such far-reaching benefits as the introduction of a stock tax or grazing fee, and this recommendation, therefore, is strongly urged. It will also tend to relieve congestion.

The fairness of a tax is recognized by everyone, when it is realized that out of the 134,000 taxpayers in the country, only 26,829 own cattle and 17,577 sheep or goats, and that individuals (not all chiefs) are making use of several thousands of acres of land, often with considerable damage to the valuable pasturage, whereas if the land was equally divided amongst the people the average size of a holding would be less than sixty acres. The tax may also be able to supply the financial needs for all improvement work in connexion with the stock of the country and including those made in this report. It may also be mentioned that a stock tax has worked satisfactorily in other Native territories, notably in Nigeria.

(7) Experimental programme.

As visualized by Sir Alan Pim, it will be necessary to carry out experiments for future guidance in the utilization of the mountain pastures. Such a scheme is outlined in Annexure F. In discussing the deterioration of the pastures the need for these experiments has already been stressed and nothing further need be said here.

(8) Additional staff requirements.

**B. Miscellaneous.**

(9) Agriculture.
- (a) Exchange of wheat and maize
- (b) Encouragement of wheat eating.
- (c) Soil erosion control.

(10) Flora reserves.

(11) Restriction of grass burning.

This is a difficult subject on which to legislate or enforce tribal rules. Yet there is no doubt that considerable damage is resulting from too frequent burning, or burning where it is not at all necessary, in Basutoland. Fortunately the practice is largely confined to the time of year (early spring) when it appears to do the least damage.

We feel that the most practical recommendation to make on this subject is that tribal rules should be enforced (on the same principle as Moshesh's law in regard to stock theft) prohibiting the burning of pastures two years in succession or at any time except early spring. Active propaganda for a few years first would appear to be advisable.

(12) Concentration of the population into reasonable-sized villages in the mountain area.

(13) Clearly define all cattle post areas.

* * * * *

The following Annexures are provided :—

A. Short general report on the geology of the extreme northern and north-eastern portions of Basutoland. By F. A. Venter.
B. List of plants with their vernacular names.
C. Vegetation map of mountain area.
D. Map showing distribution and rate of stocking in 1931 and 1936.
E. Notes on the important pasture species.
F. Proposed scheme of pasture experiments to serve both the mountain area and the lowlands of Basutoland.

The titles and objects of the fifteen experiments which are proposed are given below. This scheme has been made as simple as possible in view of the limited facilities available. It will not be possible to determine total yield of herbage or of nutrients other than that of grazing days, but it is considered that the pasture research in progress in the Union of South Africa itself should be a useful guide. None of the latter work, however, is being carried out under conditions resembling those of the high mountain pastures of the Maluti ; a larger programme of work has, therefore, been suggested for Mokhotlong than for the Lowland Station. In the detailed suggestions for these pasture experiments given in the Report, instructions are given regarding size of plots, number of plots, treatment and methods.

LOCATION OF EXPERIMENT

| Experiment number | |
|---|---|
| 1 to 8 | Mokhotlong. |
| 9 to 11 | Sani Path. |
| 12 | Thaba-Bosiu and Thaba-Tsoeu. |
| 13 to 15 | Maseru. |

**1.** Grazing system for high mountain pastures.

*Objects.*—To study the effect on the sward and on the incidence of scrub growth (*Chrysocoma tenuifolia*) by reserving the pastures on the northern slopes in which

scrub has encroached for winter grazing. Grazing in summer, will, therefore, be restricted to the *Festuca-Danthonia* (letsiri) pastures on the southern slopes. The control of the scrub encroachment is especially aimed at, but it is also important to determine the effect on the *Festuca-Danthonia* pasture of continuous summer use.

**2.** Influence of time of rest on *Themeda* and *Festuca* swards at 8,000 feet.
*Objects.*—To study the effect on the sward of different periods of rest from grazing on the two most important high mountain grassland types. The main object is to obtain information which may lead to an improvement on the simple system of deferred grazing recommended for these areas.

**3.** Effect of a deferred system of grazing on the carrying capacity and sward of a mixed Themeda pasture at 7,600 feet.
*Objects.*—To test the efficacy and protection to the grass cover which the system of grazing, recommended for village areas, may afford as compared with a system of deferred grazing in which each portion is rested for two seasons in succession.

**4.** Effect of burning on a *Festuca-Danthonia* (letsiri) sward.
*Objects.*—To study the effect of burning on this type of pasture and, if found necessary for the protection of the more valuable species, the most effective frequency and time of burning.

**5.** Effect of burning on a *Themeda* (seboku) sward.
*Objects.*—To study the effect of burning on this type of pasture.

**6.** Effect of burning on a *Chrysocoma* scrub (Sehalahala) pasture.
*Objects.*—To determine the value of burning in the control of scrub growth.

**7.** Effect on the sward of the grazing of sheep as compared with that of cattle.
*Objects.*—To obtain some information on the relative effect of the grazing of sheep and cattle on the two main pasture types. The questions of mixed grazing and the grazing of goats on the pasture sward will be studied later.

**8.** Pasture plant trials.
*Objects.*—To introduce pasture plants to the mountain area which may be superior in their pasture qualities, and particularly in ability to withstand close grazing, to the local species. Varieties are specially required which are able to establish themselves without any preparation of the soil apart from burning and the treading of stock. *Bromus unioloides* (rescue grass) is already playing a useful role in this respect in some parts of the mountain area. The general high humidity and fertile soil conditions promise a greater measure of success on these lines than in most South African conditions.

*Species to be tested.*—(1) *Bromus unioloides* (rescue grass); (2) *Bromus inermis* (Hungarian brome grass); (3) *Lolium perenne* (perennial ryegrass, N.Z.); (4) *Dactylis glomerata* (cocksfoot); (5) *Agropyron repens* (couch grass); (6) *Paspalum dilatatum*; (7) *Agrostis tenuis* (brown-top N.Z.); (8) *Trifolium repens* (white clover N.Z.); (9) *Poa pratensis* (Kentucky blue grass); (10) *Holcus lanatus* (Yorkshire fog); (11) *Poa nemoralis* (?) (Basutoland Kentucky); (12) *Agropyron* sp. (western wheat grass U.S.A.). As time goes on, other likely species can also be tried; any promising indigenous species can be planted out in these plots and kept under observation.

**9.** Grazing system for high mountain pastures at 9,500 feet.

*Objects.*—These are the same as for Experiment 1. The Mokhotlong reserve is in a rather dry locality and it is thus advisable to carry out the experiments in a simplified form under the colder and more humid conditions of the higher altitudes.

**10.** Effect of burning on a *Festuca-Danthonia* sward at 9,500 feet.

*Objects.*—This series of plots, in which the treatments are exactly the same as in Experiment 4, has been added as there is no really typical *Festuca-Danthonia* grassland on the Mokhotlong reserve.

**11.** Effect of burning on a *Chrysocoma* scrub (sehalahala) pasture.

*Objects.*—This experiment is a duplicate of that outlined in Experiment 6 as it is advisable to carry it out under the higher altitude limit in which there is a tendency for scrub to encroach.

**12.** Effect of burning and winter use on a mixed *Themeda-Chrysocoma* pasture at 8,500 feet.

*Objects.*—Chiefly to demonstrate and to test out further the method of use of the northern slopes which has been recommended in the system of grazing for the cattle post areas and to obtain information on the carrying capacity and the effect of burning. These two localities also receive an appreciably higher rainfall than the Mokhotlong area.

**13.** Deferred system of grazing for the lowland pastures.

*Objects.*—To test out a simple grazing system for the lowlands. The same system of deferred grazing is recommended for the village pastures of the mountain area.

**14.** Influence of the time of rest on an *Eragrostis* sward (typical lowland pasture).

*Objects.*—To study the effect on the sward of different periods of rest from grazing on the typical lowland pasture. The main object is to obtain information which may lead to an improvement on the simple system of deferred grazing recommended for the lowland pastures.

**15.** Comparative value of selected established pastures to the natural veld. *Objects.*—A few instances were seen of established pastures, which appeared to be very much superior in both carrying capacity and quality to the natural sward. Moreover, shortage of grazing has been acute for many years in the lowlands—a shortage which undoubtedly could largely be met by the planting of suitable species. It is doubtful whether under present conditions the Basuto could be induced or even allowed to establish permanent pastures, but doubtless this will come in time and will be hastened by suitable demonstrations and propaganda. Data on the comparative value of such pastures compared with the natural veld will also be useful. It is suggested that a start should be made with only three species :—(1) Kikuyu grass; (2) Rhodes grass; (3) Woolly finger grass.

# CONFERENCES

### Massachusetts Institute of Technology Spectroscopy Conference

INCLUDED in the Conference programme was an address by Dr. B. C. Brunstetter, of the U.S. Bureau of Plant Industry in which he outlined a five-year exploratory programme designed for the purpose of discovering the effects of nitrogen, phosphorus and other elements on the growth and chemical composition of various forage plants. The abstract quoted below is taken from *Science*, Vol. 88, No. 2274, July, 1938, Supplement p. 9.

" Eighteen different kinds of grasses and legumes were grown in Maryland for the investigation, including types of plants most common in pastures in the north humid part of the country. These were fed various fertilizers and then spectrographically examined to determine their content of such important mineral substances as magnesium, manganese, aluminum, copper, iron, potassium and calcium.

" Principally the study furnished important background material on the mineral content of plants grown in Maryland soil and under that region's climatic conditions. Dr. Brunstetter emphasized that any interpretation or application of the findings must await similar analyses on similar plants but under different environmental conditions. Only such comparisons, he said, can hope to lead to the discovery of laws governing the absorption of phosphorus, nitrogen and potassium by forage plants. Dr. Brunstetter suggested that additional similar studies would probably bring to light cases where the soil is deficient in one or more of the elements essential to plants.

" Dr Brunstetter also pointed out that those elements essential to plants are also usually essential to animal life. Thus while milk is an excellent source of minerals for man, the amount of these minerals contained in the milk is largely dependent on the amount found in the forage grasses eaten by cows. This in turn depends on the amount in the soil in which the grasses are grown."

Dr. A. T. Myers, Dr. H. L. Wilkins and Dr. M. A. Hein, all of the Bureau of Plant Industry, are collaborating with Dr. Brunstetter in the research.

### Oxford Farming Conference

A Fourth Oxford Farming conference will be held under the joint auspices of the School of Rural Economy, the Agricultural Economics Research Institute and the Institute for Research in Agricultural Engineering of the University of Oxford, on January 3 to 5, 1939. Previous conferences noted in *Herbage Reviews* appear in Vol. 4. No. 4. 1936. p. 175 and Vol. 5. No. 4. 1937. p. 208.

The Fourth Farming Conference will deal essentially with the business organization of the farm. Sessions have been provisionally arranged in which emphasis will be laid on (1) the effective organization of farm labour ; (2) considerations concerning overhead costs and labour economy (including the productivity of labour, building lay-out and general farm equipment) ; (3) the problem of agricultural credits ; and (4) land improvement under existing conditions.

## Eighth International Congress of Tropical and Subtropical Agriculture

The International Federation of Technical Agriculturists has been delegated by the Ministry of Italian Africa, to undertake the organization of the Eighth International Congress of Tropical and Subtropical Agriculture, which will be held in Tripoli from March 13 to 17, 1939. The Royal Institute of Agronomy for Italian Africa in Florence is to co-operate with the above Federation in carrying out the organization work of the Congress.

This Eighth Congress follows those held in Paris (1905), Brussels (1910), London (1914), Seville (1929), Antwerp (1930), Paris (1931), and again in Paris (1937). The aims of the Congress are (1) to consider the scientific, technical and economic problems relating to the agriculture of tropical and subtropical countries, and (2) to ascertain the results so far obtained, with the object of discovering methods of improving tropical and subtropical agricultural production.

An " Invitation" has been published by the Executive Committee in which the various sections into which the Congress is to be divided are named. This "Invitation" will be followed eventually by a detailed programme now being printed.

The Congress programme will include the following sections :

Joint : Political and colonial.
1st : Farming efficiency of tropical and subtropical countries.
2nd : Agricultural problems.
3rd : Economic problems.
4th : Products of tropical and subtropical countries.
5th : Counteracting adverse climatic factors and controlling pests and diseases.

## International Congress of Agriculture

The Eighteenth International Congress of Agriculture will be held at Dresden on June 6 to 12, 1939. The German Organization Committee has issued a Bulletin (No. 1) with the object of laying a foundation for the work to be carried out by the Publicity Committees to be appointed in the various countries, and has also announced that February 15, 1939, is the last date on which Congress papers may be sent in.

The Congress will be divided into the following nine sections :

1. Agrarian policy and farm management.
2. Agricultural instruction and propaganda.

3. Agricultural co-operative societies.
4. Cultivation of plants.
5. Viticulture, fruit-growing and the cultivation of special plants.
6. Animal production.
7. Agricultural industries (including the artificial drying of fodder plants for the purpose of obtaining fodder rich in protein).
8. Rural life and the work of the countrywoman.
9. Agricultural sciences (including the organization and encouragement of research in the field of agriculture).

Inquiries in connexion with the Congress should be addressed to Dr. F. Sohn, Generalsekretariat des XVIII. Internationalen Landwirtschaftskongresses, Berlin SW 11, Hafenplatz 4.

## Fifth International Grassland Congress

The Congress is arranged to be held in the Netherlands in 1940 under the auspices of the International Grassland Congress Association, which has its central office in Leipzig, Germany, Johannisallee 23. The organization of the Fifth Congress and the issuing of invitations have been undertaken by the Netherlands.

### Plan of Congress

The paper-reading sessions will be held on June 27 to July 2.

After the sessions a tour will be made by motor coach through the most interesting pasture lands of the Netherlands from July 2 to 9. The Agricultural College at Wageningen, some experiment stations and agricultural instructional centres will be visited. A thorough inspection of the drained Zuider Zee land will be made.

### Congress Fee

For participation in the Congress a charge of Fl.20 will be made, which will entitle members to attend all sessions and to receive the printed transactions of the Congress. Members of the International Grassland Congress Association will be charged Fl.10.

All participants will be asked to deposit the Congress fee on a date to be specified later. Only those who have made this payment can be accommodated at the Congress. The Congress fee for ladies accompanying members will be Fl.10, likewise payable in advance. The payment of this fee will admit to full membership of the Congress, but will not entitle such members to receive the Congress publications.

Members of the International Grassland Congress Association will receive the Congress publications free of charge.

All payments in connexion with the Congress must be made in Netherlands currency (guilders).

Those unable to participate in the Congress but desirous of receiving the publications may do so upon payment of the Congress fee of Fl.20.

## Paper-Reading Sessions

Plenary sessions will be alternated with sectional sessions. So far as possible, not more than two sectional sessions will be held at the same time. Plenary papers must not take more than forty-five minutes to deliver, other papers not more than twenty minutes.

## Papers

The Netherlands Executive Committee of the Congress will invite members to present papers at the plenary sessions and at some of the sectional sessions. Any member of the Congress may offer to present a paper. As the time for the sectional sessions is limited, the Executive Committee reserves the right to make a selection. Papers conforming to the sectional divisions will receive preference.

Plenary papers must not exceed 2,800 words and sectional papers must not exceed 1,400 words.

Papers should contain full reports of the author's conclusions, but technical and local details more suitable for the usual scientific journals should be omitted. Photographs, diagrams and tables should only be included if absolutely necessary, and in that case must be ready for the press. A caption in English or German should be supplied.

Scripts should be typed on one side of the paper only, and should be ready to send to the printer, as it will hardly be possible to submit proofs to authors.

Short summaries (not exceeding 300 words) in English and German must be in the hands of the Secretary at Bilthoven on or before January 15, 1940. The Central Office at Leipzig is prepared to undertake the translation of summaries into English or German, provided such summaries are received not later than December 31, 1939.

The full text of the plenary and sectional papers should reach the Secretary at Bilthoven not later than February 15, 1940.

The Secretariat hopes to publish all the plenary and other papers in printed form, in English or German, or, if necessary, in another language.

The final report, containing the discussions, etc., will appear in the autumn of 1940.

As the subsequent Congress is to be held in Hungary, which has dry climatic conditions, and it is desired to limit the scope of discussion, the special problems of arid regions will not come under consideration in 1940.

## Sections of the Congress

(1) Soils, manuring.
(2) Genetics, breeding, seed production.
(3) Grassland sociology and ecology. Botanical analysis of grassland.
(4) Management and utilization of pastures. Farm organization questions.
(5) Fodder value of pastures. Fodder conservation.
(6) Grassland problems in humid tropical and subtropical regions.
(7) Establishment and management of sports grounds and airport landing grounds.

Each section will have a President and at least two Vice-Presidents, who will take charge of the sectional meetings for certain subjects.

It is open to the Presidents and Vice-Presidents themselves to participate, if possible, in the organization of their sections.

Information concerning invitations to deliver plenary and sectional papers will be circulated as soon as possible.

ADDRESS OF SECRETARIAT

Dr. C. K. VAN DAALEN,
Secretary, Fifth International Grassland Congress,
Bilthoven, Holland.

# ANNOTATIONS

## U.S.A. (748)

### Pennsylvania Agricultural Experiment Station

A Guide to the Agricultural Experiment Station was issued in May, 1938, as Bulletin 360 of the Pennsylvania State College School of Agriculture and Agricultural Experiment Station, State College, Pennsylvania. The Guide is divided into the following five sections.

1. General information about the College.
2. Organization and functions of the School of Agriculture.
3. Research programmes of departments.
4. Physical facilities.
5. Inspection of experiments on the College Farm.

In Section 5 (pp. 25-44), the following are among the experiments listed.

| | |
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| Persistency of white clover. | Breeding clover. |
| Quick drying of hay. | Pasture research. |
| Strip cropping. | Soil conservation in orchards. |
| Grass breeding. | Soil Conservation Experiment Station. |
| Maintenance of fine turf. | Grasses for hillside pastures. |

The research programme of the United States Regional Pasture Research Laboratory situated at State College has been described by R. J. Garber (*Herb. Rev.* Vol. 6. No. 3. 1938). The research in progress on the Soil Conservation Experiment Station is described elsewhere in this issue of *Herb. Rev.* (pp. 271).

### Regional Research Laboratories

According to *Science*, Vol. 88, No. 2278, pp. 181-2, 1938, Secretary Wallace has announced that research laboratories authorized by the Agricultural Adjustment Act of 1938 will be established in four major farm-producing areas. The surplus farm commodities on which work will be done during the initial programme have been named. Four regional research laboratories for studies on new uses and market outlets for agricultural products are to be established. According to the law the funds available ($4,000,000) must be divided equally among the four. The areas

are to be known as the Southern, Eastern, Northern and Western major farm producing areas. The states included in these areas are :

Southern Area : Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Oklahoma, South Carolina and Texas.

Eastern Area : Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia and West Virginia.

Northern Area : Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Michigan.

Western Area : Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

Work in the initial stages of the programme will be concentrated on the following farm commodities and their by-products : In the southern laboratory, cotton, sweet potatoes and peanuts ; in the eastern laboratory, tobacco, apples, Irish potatoes, milk products and vegetables ; in the northern laboratory, corn, wheat and agricultural waste products ; in the western laboratory, fruits (other than apples) and vegetables, Irish potatoes, wheat and alfalfa.

Secretary Wallace is planning a conference in each of the areas to consult with research institutions and representatives of producers and of industries.

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